BRACHIAL ARTERY, ITS BRANCHING PATTERN AND VARIATIONS WITH ITS CLINICAL APPLICATIONS

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CERTIFICATE

This is to certify that the dissertation on **"BRACHIAL ARTERY, ITS BRANCHING PATTERN AND VARIATIONS WITH ITS CLINICAL APPLICATIONS"** is the bonafide work done by **Dr.V.SATHIA LAKSHMI,** in the Institute of Anatomy, Madras Medical College, Chennai - 600 003, during 2003 - 2006 under my supervision and guidance in partial fulfilment of the regulation laid down by Tamil Nadu **Dr.M.G.R. Medical University,** for the M.S. Anatomy Branch V examination to be held in September 2006.

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CONTENTS

AIM OF THE STUDY

"Any thing out of sight is out of mind"

A basic law of anatomy is that the only thing which remain constant is its variability. Striking variations in origin and course of the principal arteries of the upper extremities have long received the attention of anatomists and surgeons. Now a days cardiologists and radiologists are utilizing the brachial artery with increasing frequency for catheter based diagnostic and therapeutic intervention procedures. It is gaining importance because brachial approach allows early ambulation and discharge.

Brachial artery is used in diagnostic angiography, cardiac catheterisation for angioplasty, carotid stenting, transbrachial access for endovascular renal artery intervension, embolectomy through arteriotomy on branchial artery is done. Apart from the above mentioned procedures, accidental intra arterial injections, ligation of artery instead of vein have been reported. In order to avoid all these catastrophes accurate knowledge of this major arterial conduit in relation with its course and particularly of their variational branching pattern is of considerable practical importance.

Thus an interest in the anatomy of this clinically so important brachial artery was a stimulus for me to pursue this study in a detailed manner. Isolation of the brachial artery and tracing of the branches was done to know more about it than already documented and thereby hoping to add more information to guide the operating surgeons, cardiologists, vascular surgeons and anaesthetists.

The present study of brachial artery was undertaken by me to study the variation in the branching pattern. It was also studied under the following parameters.

1. The length of the brachial artery from the teres major tendon to the inter condylar line,
2. Point of bifurcation in relation to intercondylar line,
3. Variation in branches :
    a. profunda brachii
    b. superior ulnar collateral artery
    c. nutrient artery of the humerus
    d. inferior ulnar collateral
    e. terminal branches
    f. superficial brachial artery
4. Brachial artery's relation to median nerve

REVIEW OF LITERATURE

Quains (1844) was believed to be the first person to provide data sufficient for useful statistical evaluation regarding brachial artery. In his series of dissection with 481 extremities he encountered 19.5% of anomalies of radial artery. He reported 0.2% prevalence superficial brachial in 506 extremities he dissected, presence of an anastomotic vessel in the antecubital fossa in 2.5% and presence of superficial ulnar artery 1.7%.

Gruber (1848) came across 8.6% of variations of the brachial artery in 1200 extremities. He reported 5 cases (0.4%) of superficial brachial artery with an incidence of 0.5% of the anastomotic vessel in the antecubital fossa.

Gray (1858) in his "Text Book of Grays Anatomy" He describes that the brachial artery is the continuation of the axillary artery, which begins at the inferior border of Teres Major Muscle and ends about 1 cm distal to the elbow joint at the level of the neck of the radius.

Poirier (1886) has discussed in his text book of anatomy regarding the superficial brachial artery, in hundred dissection he found superficial brachial in 6% cases i.e. brachial artery crossed superficial to the median nerve in 6 limbs. High origin of the ulnar artery was found 20 times in 440 dissection. High origin of the radial artery according to Poirier was rare.

Muller (1903) appreciated 14% of variation in the brachial artery in his dissection with 100 limbs, and came across 1% superficial brachial artery, 2% superficial ulnar artery and pointed out 6% presence of an anastomotic vessel in the antecubital fossa.

Hofer & Hofer (1910) described a case in which brachial artery passed between the two heads of pronator teres instead of dividing above it, but they were unable to find a similar case in literature.

Linell (1921) among the 34 limbs dissected he demonstrated two instances in the same body in which the median nerve crossed deep to the brachial artery.

Beuntaro Adachi (1928), a Japanese anatomist described that brachial artery normally run deep to the median nerve. When a large

arterial trunk runs superficial to the nerve, this is the "arteria brachialis superficialis". It may replace the main trunk, or it may be accompanied by an equally important, less important, or more important trunk running parallel and deep to the median nerve in the normal position. In these cases the superficially placed vessel may continue as the radial or more rarely as the ulnar artery. He further subdivided the "arteria brachial superficialis into superior, medial and inferior according to its point of origin for the main arterial trunk. The point of origin may be from the axillary, most frequently it is from the upper part of the brachial, but a "superficial brachial artery" may also arise from the lower part of the brachial artery nearer the elbow.

Degaris & Swartley (1928), the authors recognised 23 different patterns of axillary artery and its braches in their study based on 512 dissection and about 0.8% of high origin of ulnar artery and 7.7% of high origin of radial artery. He also pointed out 9% of prevalence of superficial brachial artery.

Huber (1930), describes that inferior ulnar collateral artery a branch of brachial artery begins 4 cm above the termination of the brachial artery. Some times brachial artery accompanies median nerve

behind the supracondylar process of humerus from which a fibrous arch is most often thrown over the artery. This condition resembles the normal condition in some carnivores.

Piersol (1930) in his text of human anatomy had written that variations which the brachial artery presents are numerous and important, in that they affect materially the origin of the two terminal branches, the radial and ulnar. In cases in which there is a well-developed supracondylar process on the humerus the brachial artery accompanies the median nerve behind it, and only passes upon the anterior surface of the arm after it has passed it. In such cases there generally arises from the upper part of the brachial or even from the axillary, a vessel which descends upon the anterior surface of the arm, lying superficially and sending branches to the biceps and brachialis muscles. This has been variously termed the vas aberrans, the a. brachialis superficialis, or the a. radialis superficialis, and it appears to be normally present, but much reduced in size and included among the muscular branches. The majority of the modifications of the brachial artery are due to an extraordinary development of the superficial brachial. Thus it may enlarge and become continuous below with the radial artery, giving rise to a condition usually

termed a "high" origin of the radial; more rarely it may unite with the ulnar artery, producing a "high" origin of ulnar vessel.

Charles *et al.,* (1931) made a study of the types of origin of the profunda brachii artery in 300 dissections and specified 7 types of origin for profunda brachii artery.

Type I : Branch of brachial artery in 54.7% cases.

Type Ia : Origin of arteria profunda brachii by 2 separate branches seen in 0.7% dissections.

Type Ib : Origin of arteria profunda brachii by 3 separate branches seen in 0.3% dissections.

Type II : Arising as a common trunk with superior ulnar collateral in 22.3% cases.

Type III : Arising at lower border of teres major so can be considered to be arising from axillary or brachial in 8% cases.

Type IV : Branch of 3rd part of axillary artery in 8.7% cases.

Type V : Arising as a common trunk with posterior circumflex humeral in 4% cases.

Type VI : Arising as a common trunk with subscapular and both circumflex humerals from axiallary artery in 0.7% cases.

Type VII : Absent arteria profunda brachii in 0.7% cases.

Polanskaja (1932) pointed out that the smaller branches of brachial artery, especially those which anastomose around the elbow to form the collateral circulation, have no constant pattern. He further added that he was never able to find the same pattern even on the 2 sides of one body.

Singer (1933) Considered the high origin of radial artery as a kind of persistent superficial brachial artery.

Schwyzer & DeGaris (1935) reported two cases of superficial brachial artery dividing into radial and ulnar arteries in the cubital fossa and then the ulnar artery going superficial to all flexor muscles of forearm in one case and all but palmaris longus in the other; the brachial artery continued in the arm as interosseous complex. They called this ulnar artery as arteria antebrachii superficialis ulnaris.

J.E. Frazer, Professor, University of London (1937). In his text book of 'A manual of anatomy". Had written that the brachial artery may divide at a higher level than usual. In most cases the abnormally early branch is the radial; more rarely it is the ulnar, and in these cases the interosseous trunk arises from the radial; still more rarely the premature branch is the interosseous trunk, or a large vas aberrans. The level at which a high division takes place is most frequently in the upper third of the arm, less frequently in the lower third, and rarely in the middle third. When two arteries are present, they usually lie one in front of the median nerve and the other behind it. When a vas aberrans is present, it usually arises from the upper part of the brachial artery, lies in front of the median nerve, and terminates below by joining, most commonly, the radial artery. In rare cases the brachial artery divides high up into two vessels of equal size, which become reunited into one trunk a little above the elbow.

Miller (1939) in his dissection with 480 bodies came across about 3% superficial brachial artery. And he believed that superficial brachial artery is an atavistic condition, since a main brachial artery crossing superficial to median nerve is said to be the usual arrangement in the primates.

Massie (1944) said arteria profunda brachii is also known as superior profunda, superior ulnar collateral as inferior profunda and inferior ulnar collateral as arteria anastomotica.

Treves & Rogers (1947) described the presence of 2 arteries instead of one brachial artery. These 2 arteries may be (a) radial & ulnar, (b) 2nd branch may be interosseous which has originated high up from arteries at normal position, (c) the 2 vessels may be normal brachial and a vas aberrans.

Thorek (1951) says that brachial artery gives 3 main branches (profunda brachii, superior ulnar collateral and inferior ulnar collateral). He called superior ulnar collateral as inferior profunda.

Lawrence J. McCormack, *et al.,* **(1953)** in their total series which comprised of 750 consecutive upper extremities. 139 (18.53%) presented major variations in respect to the origin and course of brachial or antebrachial arteries. Instances of origin of the radial artery proximal to the inter condylar line form the largest group of the gross variation which represented 14.27%. He pointed out the presence of an anastomatic vessel in the antecubital fossa 2.8% i.e. in case of high origin of radial and ulnar

artery he demonstrated the presence of a large anastomotic connection between the radial and ulnar arteries in cubital fossa (Fig.1 & 2)

J.C.Boileau Grant (1958) in his book "A Method of anatomy Descriptive and Deductive" had written that the brachial artery is the largest artery whose walls can be felt satisfactorily in the living subject. It may be palpated along the medial bicipital furrow throughout the length of the arm to the point where it disappears behind the bicipital aponeurosis. At the level of the neck of the radius, 1" below the transverse crease of the elbow, it divides into its two terminal branches, larger ulnar artery and smaller radial artery.

W.Henry Hollinshead (1958) in his book "Anatomy for surgeons : Volume III" has described brachial artery as the continuation of axillary artery, the change in name occurring at the lower border of the teres major muscle.

Skopakoff (1959) gives the percentage frequency of all types of "superficial brachial artery" as 19.7% (610 dissections). The author includes several instances of comparatively small branches of the brachial which ran superficial to the median nerve and resolved themselves into muscular branches without a downward continuation.

J.A.Keen (1961) in his series of 284 dissections found that profunda brachii was often represented by more than one trunk which follow the radial nerve. In 26% (284 dissections) the profunda brachii arose from the terminal part of the axillary artery, i.e., the origin was from the main arterial trunk at a level above the lower border of the teres major tendon. In 6% the profunda brachii arose as a branch of the posterior circumflex humeral, or of the subscapular in the case of a common trunk for these two vessels. A third abnormality of the profunda brachii is its origin from the posterior circumflex humeral artery. He also encountered about 12.3% of superficial brachial artery. He sub divides superficial brachial artery into 3 types.

a. Those superficial brachial artery which continue in the cubital fossa and bifurcate as usual into radial and ulnar arteries (3.6%).

b. Superficial brachial continues as radial artery and known as high origin radial artery (5.9%).

c. Superficial brachial artery continue as ulnar artery and known as high origin of ulnar artery (2.8%).

Romanes (1964) has described that brachial artery some times accompanies median nerve behind the supra condylar process of humerus from which a fibrous arch is most often thrown over the artery. This condition resembles normal condition in carnivores. He also pointed out high origin of ulnar artery but with out statistics.

Anson (1966) in his dissection came across, 15% of high origin of radial artery. In the arm, it lies anterior to median nerve and in the forearm it takes normal course. He also demonstrated the profunda brachii arising from brachial artery in 55%. 22% profunda brachii arising as a common trunk with superior ulnar collateral. 16% as a branch of third part of the axillary artery and 7% as a common trunk from posterior circumflex humeral artery. According to him superficial brachial arises from axillary artery or from proximal 1/3 of brachial artery usually between the contributions of medial and lateral cords of brachial plexus to the median nerve. It is superficial to muscles of the arm under brachial fascia lying slightly more lateral than the brachial artery and in the elbow region divides into radial and ulnar artery.

Vare and Bansal (1969) reported a case with high division of brachial artery - the superficial brachial artery giving rise to radial and ulnar artery while deep division continuing in the forearm as interosseous complex and giving a large median artery which in the palm formed superficial palmar arch with ulnar artery.

C.J.Romanes (1972) in Cunningham's Textbook of Anatomy had written that the brachial artery sometimes divides at a higher level than usual. In such cases the ulnar artery may cross superficial to the flexor muscles, and may even be subcutaneous; and the radial artery may descend in the superficial facsia of the forearm. In performing venesection at the elbow such variations have to be borne in mind. Sometimes the brachial artery accompanies the median nerve behind a supracondylar process, or ligament; and it may pass in front of the median nerve instead of behind it.

Karisson and Niechajev (1982) in angiographic observations, found high origin of radial artery in 10% patients, the parent trunk being axillary artery in 12.5%, proximal 1/3 of brachial in 62.5% and middle 1/3 of brachial in 25%. They could find high origin of ulnar artery in 1% cases only.

Lippert and Pabst (1985) had reported 22% prevalence of superficial brachial artery and also considered high origin of radial artery as a kind of persistent superficial brachial artery.

Jurjus a, Sfeir R, Bezirdjian R. (1986). They had reported an anomalous brachial artery, after giving off a profunda brachii artery with no collaterals, divides in its upper one-third into two equal-sized arteries, brachial arteries 1 and 2. These arteries lie next to each other in the normal path of the brachial artery. Brachial artery 1 is possibly a high-origin and persisting radial artery. It gives no collaterals in the arm. At the cubital fossa, it becomes subcutaneous and divides into two equal - sized radial and ulnar arteries. These arteries run completely superficial to flexor muscles of the forearm and are terminated by branches running above the thenar and hypothenar eminences, respectively. Brachial artery 2 is possibly a high origin artery of the common interosseous. The course of this artery resembles the course of the brachial axial artery of the embryo. It supplies the anterior compartment of brachial muscles and continues as the common interosseous artery. This common interosseous artery in turn branches into the superior and inferior ulnar collaterals, and the anterior and posterior interossei. It does not regress, but has a major role in forming the deep palmar arterial arch in the hand.

Lengele B, Dhem A. (1989) in their routine dissection came across three cases of multiple anomalies involving the vessels and nerves of the axilla. The main common characteristic between them was the unilateral existence of a superficial brachial artery.

Nakatani T, Tanaka S, Mizukami S. (1996) they described rare anomalies of the bilateral superficial brachial arteries in a dissected 69-year-old Japanese man in the gross anatomical course. The right and left superficial brachial arteries were observed to originate from the axillary artery, pass over the lateral root of the median nerve, course laterally and superficially to the median nerve, and split into the radial and ulnar arteries in the cubital fossa. The right brachial artery ended in the posterior aspect of the elbow. The left brachial artery ended in the anastomosis with the ulnar artery at the site opposite to the origin of the common interosseous artery. These arterial patterns can be explained by the existence, during the developmental process of the arteries of the arm, of a superficial brachial artery and an anastomotic branch between the superficial brachial and brachial arteries.

Yucel AH (1999) described unilateral variation in the origin and distribution of the arterial pattern of the human upper extremity on the right side. Apart from its usual branches, the third part of the right axillary artery gave origin to a common branch, the profunda brachii artery and the superior ulnar collateral artery. The right brachial artery, at a point 5.0 cm distal to its origin, bifurcated into the radial and ulnar arteries; their origin was in a position opposite the usual location. The radial artery continued on the medial side of the arm for 2.5 cm and crossed the ulnar artery anteriorly to gain a lateral position in the arm. The inferior ulnar collateral artery arose not from the brachial artery, but from the ulnar artery.

William *et al.,* **(1999)** described the brachial artery, as the continuation of the axillary artery from the distal (inferior) border of the tendon of teres major and ends about a centimeter distal to the elbow joint (at the level of the neck of the radius) by dividing into radial and ulnar arteries. At first it is medial to the humerus, but gradually spirals anterior to it until it lies midway between the humeral epicondyles. Its pulsation can be felt throughout. They also said the nutrient artery of the humerus arises near the mid-level of the upper arm, and enters the nutrient canal near the attachment of coracobrachialis.

Rodriguez-Baeza A, Nebot J, Ferreira B, Reina F, Perez J, Sanudo JR, Roig M. (2000) they reported 23 cases with variations in the brachio-antebrachial arterial pattern of the human upper limb are reported. According to them the brachial artery showed, 4 groups of variation;

1. Isolated persistence of the median artery;
2. High origin of the ulnar artery;
3. High origin of the radial artery; and
4. Duplication of the brachial artery, either with or without anastomosis at the cubital fossa.

Kumar MR. (2004) in a routine dissection of a female cadaver, came across a variation in the course of the radial artery in the cubital fossa and a communication between the brachial artery and radial artery were observed. A rare origin and course of the median artery was also found.

DEVELOPMENTAL ANATOMY OF UPPER LIMB VASCULATURE

NORMAL DEVELOPMENT

When the upper limb buds are formed in the 4th week of intra uterine life, a number of small arteries arise from the dorsal aorta and pass into the limb bud to form capillary network which drain into the anterior cardinal veins. Out of these small arteries only one persists as the axis artery of the upper limb. And it shifts its origin to the lateral branch of the 7th cervical into segmental artery. This axis artery grows deep to the muscle mass in the forearm and terminates in superficial and deep capillary plexuses of the developing hand. Digital arteries develop from the capillary plexus. (Fig.3)

Proximal part of the main trunk forms the axillary artery and brachial arteries, and its distal part persists as the anterior interosseous artery and the capillary plexus in which it ends forms the deep palmar arch.

High in the forearm a branch from the axis artery passes dorsally between the radius and ulna and forms the posterior interosseous artery.

A little below that point, another branch of the axis artery accompanies the median nerve and called the median artery reaches the superficial capillary plexuses of the hand. Thereafter the distal part of the axis artery loses its connection with the plexus.

A little below the elbow, the axis artery gives a branch which becomes the ulnar artery. It grows distally to unite with the superficial capillary plexus of the palm which later becomes the superficial palmar arch. Now the median artery regresses from about the middle of the arm, another branch is given off from the axis artery, and is called the primary radial artery. The proximal part of the radial artery above this level degenerates and disappears. The radial artery grows down to join the deep capillary plexus of the hand which forms the deep palmar arch. Thus the following structures are derived from the axis artery of the upper limb. (a) axillary artery (2) brachial artery (c) proximal part of ulnar artery (d) common interosseous artery (e) anterior interosseous artery.

EMBRYOLOGICAL JUSTIFICATION OF THE EXISTENCE OF ARTERIAL VARIATIONS IN THE ADULT UPPER LIMB

Based on the results of (Rodriguez - Niedenfuhr *et al.,* 2001b) injection studies on animal embryos and experimental data which showed that when an endothelial tube gets a muscular coating it looses its remodeling ability. They proposed that the sprouting theory described in many of the embryological and anatomical textbooks and reproduced in (Fig.4A) was absolute. The new findings suggest that the arterial pattern of the upper limb develops from an initial capillary plexus by a proximal to distal differentiation of certain capillary vessels, and the regression of others (Fig.4B). It is suggested that the persistant, enlargement and differentiation of capillaries forming the initial capillary plexus, which would normally remain in a capillary state or even regress, gives rise to arterial variations of the definitive arterial pattern, rather than the sprouting of aberrant vessels.

The establishment of the superficial brachial, accessory brachial and the brachial part of those variations affecting the arm and forearm must be determined before stage 17 as then, the arteries until the elbow would have already got a definitive morphology of its wall and no further remodeling would be possible. The variations affecting the forearm

arteries as well as the ante-brachial part of those variations affecting the arm and forearm, have to be established before stage 18 as then the forearm arteries have got their definitive wall morphology except the distal part of the radial. The superficial radial and the distal part of the superficial brachioradial arteries would be determined before stage 21 when they get their definitive morphology (Fig.4B).

MATERIAL AND METHODS

STUDY MATERIAL

The study material consists of

a) 40 upper limb specimens from 20 adult cadavers (14 males, 6 females)

b) 10 upper limb specimens from 5 full term foetuses

c) 2 clinical cases

METHODS OF STUDY

I. Conventional dissection method
   a) In adult cadavers
   b) Foetal cadavers

II. Clinical Study

I. Conventional dissection method

a) Adult cadaveric study

Twenty adult human cadavers were selected from the cadavers allotted to the I MBBS students at the Institute of Anatomy, Madras Medical College. The age and sex of the human cadavers were noted down.

The skin and superficial fascia over the arm up to lower 1/3 of forearm were carefully reflected along the conventional anatomical lines from anterior aspect. Then the deep fascia was removed, flaps reflected to uncover biceps brachii muscle, the muscle was displaced laterally.

The principal neurovascular bundle of the arm medial to biceps was identified. Then the structures in the arm were traced proximally upto the insertion of the corocobrachialis. The neurovascular bundle consist of the brachial artery and the two venae comittants. The brachial artery was dissected from the distal border of the teres major muscle and was found medial to the humerus but gradually spirals anterior to it and descended midway between the humeral condyles.

During the above procedure the profunda brachii artery was identified. It arose from the posteromedial aspect of the brachial artery distal to the teres major muscle. It was traced along with the radial nerve running between the long and medial heads of the triceps up to the radial groove.

Superior ulnar collateral was dissected a little distal to the upper arm's midlevel. It accompanied the ulnar nerve, and was found piercing

the medial inter muscular septum and descended between the medial epicondyle and olecranon.

The nutrient artery was traced from its origin near the mid level of the upper arm, and found to enter the nutrient canal near the attachment of coracobrachialis.

Inferior ulnar collateral was dissected about 5 cms proximal to the elbow joint. It was traced between the median nerve and brachialis muscle upto the point where it pierced the medial intermuscular septum. The branchial artery was dissected upto the point of bifurcation and the origin of ulnar artery and radial identified.

b) Foetal cadaveric study

Full term foetuses 5 in number were obtained from the Institute of Obstetrics and Gynaecology, Egmore, and was embalmed in formalin solution and studied.

In full term foetuses, the skin was reflected from the upper arm upto the elbow joint. The neurovascular bundle was identified. The muscles mass was pushed laterally, the brachial artery with the venaecomitants identified. The relation of median nerve studied. The

branching pattern of the brachial artery was noted. The profunda brachii artery, superior ulnar collateral artery and inferior ulnar collateral artery were identified.

During the above cadaveric dissection in adult as well as in foetus the variations of the brachial artery and its branches were photographed for documentation.

The findings of the observation were noted down as per the parameter taken for this study.

II. Clinical Study

Two cases from the Vascular Surgery Department, Government General Hospital, Chennai - 3 have been selected for the study (2 male patients of age group 20 and 25) with the following diagnosis.

Sl.No.	Name	Age	Diagnosis
1.	Navamani	20	Aneurysm of subclavian artery
2.	Kannan	25	Ulnar artery occlusion

In the above two cases the branching pattern of the brachial artery was observed by the angiographic study.

OBSERVATION

The brachial artery and its branching pattern was studied by the following methods.

I. Conventional Methods

a. In adult cadavers

b. Foetal cadavers

II. Clinical Study

Conventional dissection method

Ia. Adult cadaveric study :

40 upper limbs were taken for study. After the conventional dissection was carried out the findings were noted.

1. The length of the brachial artery from the teresmajor tendon to the intercondylar line.
2. Point of the bifurcation inrelation to the intercondylar line.
3. Branches :
    a. Profunda brachii artery also known as superior profunda artery.

b. Superior ulnar collateral artery also known as inferior profunda.

c. Nutrient artery of the humerous

d. Inferior ulnar collateral or supra trochlear artery.

e. Two terminal branches - Ulnar and Radial

f. Superficial brachial artery

4. Brachial artery's relation to Median nerve

Ia. 1. Length of the brachial artery

In all 40 specimens dissected, the length of the brachial artery was calculated as mentioned by Patnaik *et al.,* 2002. For measuring its length the following 2 points were taken.

a. The mid point of the width of the artery where it begins i.e. at the lower border of teresmajor.

b. The point of termination of the artery.

First the distance between the lower border of the teresmajor tendon and intercondylar line was measured along the artery (x) and then the distance between the intercondylar line and

termination of brachial artery where it divides into ulnar and radial arteries was measured (y). Then the length of the brachial artery was calculated by adding these two values (x + y) if the brachial artery divided below the intercondylar line, or by substracting 2nd distance from the first (x-y) if the brachial artery divided above the intercondylar line. Measurement was taken with the help of inch tape.

In one specimen the length of the brachial artery was 4cms and in another it was 2cms. The Table-1 shows the complete length of all the 40 specimens. The average length of the brachial artery was 21.5 cms. Out of 40 specimens, 11 specimens were less than the average length 21.5cms (28%) and 29 specimens were more than the average length (72%).

Ia. 2. Point of bifurcation in relation to the intercondylar line

In 40 specimens dissected 36/40 (90%) (Table 2) specimens bifurcated below the intercondylar line (Fig.5). In other 2/40 (5%) specimens the bifurcation was above the intercondylar line (Fig.6). In the remaining 2/40 (5%) the bifurcation of the brachial artery was at the intercondylar line (Fig.7).

Ia. 3. Branches

In 40 specimens dissected the profunda brachii artery, superior ulnar collateral artery, nutrient artery collateral artery and inferior ulnar and the terminal branches ulnar and radial were studied.

3a. Profunda brachii artery

In 40 specimens dissected, profunda brachii artery arose from the posteromedial side of the brachial artery in 35/40 (87.5%) specimen (Fig.8) distal to the teresmajor tendon and followed the radial nerve closely and it passed downward and outward between the medial and long head of the triceps and reached posterior surface of the humerus. (Tab.3).

In 2/40 specimens (5%) the profunda brachii artery and superior ulnar collateral artery arose from a common trunk (Fig.9).

In 1/40 specimen (2.5%) the profunda brachii artery arose from the posterior circumflex humeral artery a branch of the III part of the Axillary artery and descended deep to the teresmajor

tendon. At the inferior border of teresmajor tendon it descended posteriorly along with radial nerve (Fig.10).

In 1/40 specimen (2.5%) profunda brachii artery arose from the axillary artery (Fig.11).

In 1/40 the profunda brachii arose as 2 separate branches and both followed the course of radial nerve closely (Fig.12).

3b. Superior ulnar collateral artery

In 36/40 (90%) specimens (Fig.13) the superior ulnar collateral arose from the medial side of the brachial artery a little distal to the upper arm's mid level. It accompanied the ulnar nerve and pierced the medial intermuscular septum and descended between the medial epicondyle and the olecranon and terminated deep to the flexor carpi ulnaris by anastomoting with posterior ulnar recurrent and inferior ulnar collateral arteries. (Tab.4)

In 2/40 (5%) specimens the superior ulnar artery arose from a common trunk with profunda brachii artery (Fig.14).

In 2/40 (5%) specimen superior ulnar collateral arose as a branch of profunda brachii artery and descended between the medial epicondyle and olecranon.

3c. Nutrient artery of the humerus

In all the 40 specimens the nutrient artery arose from the brachial artery near the mid level of the upper arm, an entered the nutrient canal on its medial surface near the attachment of the corocobrachialis muscle.

3d. Inferior ulnar collateral artery

In all the 40 specimens dissected inferior ulnar collateral artery arose about 5 cms proximal to the elbow no variation were noted (Fig.15).

3e. Two terminal branches - Ulnar and Radial

In 40 specimens dissected 36/40 (90%) ulnar and radial artery arose below the intercondylar line.

In 2/40 (5%) specimens the bifurcation of the brachial artery was above the intercondylar line. So the radial and ulnar artery originated from the mid level of the arm. (Fig.6)

In 1/40 (2.5%) ulnar artery originated from the third part of the axillary artery and descended down to the palm and took part in the superficial palmar arch (Fig.17).

In 1/40 (2.5%) the radial artery arose from the brachial artery just below that teresmajor tendon and ran down the forearm up to the wrist joint and turned to the dorsal surface (Fig.16).

3f. Superficial brachial artery

Superficial brachial artery has been already described

1. Brachial artery running superficial to median nerve.

2. The axillary artery at the inferior border of teresmajor tendon gives off a superficial brachial artery branch and it continues as a deep branch of the brachial artery (Fig.18).

3. The high origin of radial artery is also regarded as the superficial brachial artery (Fig.16).

4. The high origin of ulnar artery is also termed as superficial brachial artery (Fig.17).

In 38/40 (95%) specimens dissected the median nerve formation was anterior to the brachial artery.

In 2/40 (5%) specimen the formation of median nerve was posterior to the brachial artery, and the brachial artery and it ran superficial to the median nerve (Fig.9).

In 1/40 (2.5%) specimen just below the inferior border of teresmajor tendon a superficial vessel arose from the brachial artery and it descended on the radial side superficial to all the muscles upto the wrist joint and then turned to the dorsal aspect of the hand. This vessel is termed as high origin of radial artery -a type of superficial brachial artery (Fig.16).

In 1/40 (2.5%) specimen a vessel arose from the third part of the axillary artery and descended superficially upto the palm and took part in the superficial palmar arch. This is called the high origin of ulnar artery. The brachial artery from the lower border of teresmajor tendon ran deep to the median nerve and below the

intercondylar line bifurcated into radial and common interosseous artery (Fig.17).

In one specimen 1/40 (2.5%) the brachial artery just below its origin gave off a superficial branch which ran superficial to median nerve and bifurcated into radial and ulnar artery below the intercondylar line. From the deep vessel the profunda brachii, the superior ulnar collateral nutrient and the inferior ulnar collateral arteries arose (Fig.18).

4. Brachial artery's relation to median nerve

In 38/40 (95%) specimens the median nerve was formed anterior to the brachial artery. In 2 specimens the median nerve descended down on the medial side of the brachial artery throughout. No crossing was seen (Fig.9).

In 2/40 (5%) specimens the median nerve was formed posterior to the brachial artery. (Tab.5).

Ib. Foetal cadaveric study

Length of the brachial artery

Ten arms of full term foetuses were dissected and the length of brachial artery measured.

The Table - 6 shows the length of the brachial artery from the lower border of the teresmajor tendon to the point bifurcation below the intercondylar line. The average length of the artery was 8.35cms.

In 5/10 (50%) specimens the length of the brachial artery was less than the average length (8.35cms).

In 5/10 (50%) specimens the length of the brachial artery was more than the average length (8.35cms).

Point of bifurcation of the brachial artery

In 9/10 (90%) specimens the brachial artery bifurcating below the intercondylar line.

In 1/10 (10%) specimens the brachial artery bifurcating above the intercondylar line (Fig.19).

In all the 10 specimens dissected no gross branching variations was noted.

Relation of the brachial artery to the median nerve

In 8/10 (80%) specimens the median nerve formed anterior to the brachial artery and descended along the lateral side and crossed to the medial side near the corocobrachialis muscle incertion.

In 2/10 (20%) specimens the median nerve formed running posterior to the brachial artery and descended medial to the brachial artery throughout its course (Fig.20).

II. Clinical Study

Two clinical cases were selected from Vascular Surgery Department, Government General Hospital, Chennai - 3 between the age of 20 & 25 years (Fig.21).

Sl.No.	Name	Age	Diagnosis
1.	Navamani	20	Anneursym of subclavian artery
2.	Kannan	25	Ulnar artery occlusion

For the above cases brachial arteriogram was done as an investigation procedure. In case No.1 Anneursym of subclavian artery was diagnosed and case No.2, Ulnar artery occlusion was made out.

Angiographic procedure

Retrograde axillary artery catheterization

First the patient was put in supine position. Then the left arm was abducted to the extreme and the hand was placed under the patient's head. The puncture site of the axillary artery located along the lateral axillary fold over the proximal part of the humerus so that the underlying bone provides support during compression.

The axillary artery was palpated and fixed by the left index and middle finger, a small superficial skin nick was made with a No.11 blade directly over the arterial pulse. The course of the artery was palpated while a 18 guage needle Pott's Cournaud Needle having a sharp stylet with a perforated hub was rapidly thrust down the artery. The needle was angled at 45^{o} with respect to the skin and gently advanced, when arterial blood was seen exiting from the stylet hub, the hub was removed and

catheter (Seldinger) with two way tap attached to its hind end was passed along the guide wire into the artery. The wire should not be forced.

Now, the urograffin solution (contrast) was injected to identify the course of the vessel and to find out the clinical problems like thrombosis, embolism, atheromatous plaque, stenosis or abnormal dilatations namely anneurysm.

The study was done by visualising the pictures taken serially starting from 5 minutes after injecting the contrast. Then the branches of axillary and brachial artery were noted.

DISCUSSION

The present study of brachial artery was undertaken to study the variations in the branching pattern. It was studied under the following parameters.

1. Length of the brachial artery from the teres major tendon to the point of bifurcation

2. Point by bifurcation in relation to intercondylar line.

3. Branches and variations:

    a. Profunda brachii artery

    b. Superior ulnar collateral artery

    c. Nutrient artery

    d. Inferior ulnar collateral artery

    e. Terminal branches - radial and ulnar arteries

    f. Superficial brachial artery

4. Brachial artery's relation to median nerve

I. Adult Cadaveric study

1. Length of the brachial artery from the teres major tendon to the point of bifurcation

Quain (1844), Henry Gray (1858), Poirier (1886), Adachi (1928), Piersol (1930), J.E.Frazer (1937), J.C.Boileau Grant (1957), W.Henry Hollinshed (1958), Williams (1999) all the above scientists had described the artery as the continuation of the axillary artery commencing from the lower border of teres major to the point of bifurcation of the artery below the inter condylar line. They had not given any statistical data regarding the length of the brachial artery.

Patnaik *et al.* (2002), had said that brachial artery was the continuation of the axillary artery from the lower border of teres major tendon upto its bifurcation as radial and ulnar artery. According to his study the total length of the brachial artery on an average was 26.29 cms (ranging from 20.5 to 29.0 cms).

In the present study the average length of the brachial artery was 21.5 cms (ranging from 2 cms to 26 cms). So regarding the length of the artery, my study coincides with Patnaik et al. (2002).(Tab.7).

2. Point of bifurcation of brachial artery in relation to the intercondylar line

Bifurcation of the brachial artery proximal to the inter condylar line is considered as a variation.

Quains (1844), quoted that nearly 1.7% of brachial artery bifurcated above the intercondylar line.

Gruber (1848), said that about 2% of the brachial artery in his dissection bifurcated above the intercondylar line.

Muller (1903), described about 1% of brachial artery bifurcating above the intercondylar line.

Buntaro Adachi (1928), reported 0.7% of the brachial artery bifurcating above the intercondylar line.

Degaris and Swartley (1928), said that about 0.8% of the brachial artery bifurcated above the intercondylar line.

Charles et al. (1931), reported that 10% of the brachial artery bifurcating above the intercondylar line.

Miller (1939), came across about 3% of the brachial artery bifurcating above the intercondylar line.

J.A.Keen (1961), reported about 5-9% of the brachial artery bifurcating above the intercondylar line.

Anson (1966), encountered about 15% of high bifurcation of brachial artery.

Karisson and Niechajev (1982), in angiographic observation found 10% of brachial artery bifurcating above the intercondylar line.

According to the above anatomists, bifurcation of the brachial artery above the intercondylar line varies from 0.7% to 15.0%. All the above anatomists have not given statistical data regarding the bifurcation of the brachial artery below the intercondylar line and also bifurcation at the intercondylar.

In the present study, in 5% cases brachial artery bifurcated above the intercondylar line. In 90% cases brachial artery bifurcated below the intercondylar line. And in 5% brachial artery bifurcated at intercondylar line. Hence, regarding the point of bifurcation of brachial artery from the

intercondylar line, my study coincides with the anatomists Miller (1939) and J.A.Keen (1961). (Table.8).

3. Branches and variation

a. Profunda brachii artery

The origin of arteria profunda brachii is quite variable. **Charles et al. (1931)** specify 7 types of origins for this artery.

Type I : Branch of brachial artery in 54.7%

Type Ia : Origin of arteria profunda brachii by 2 separate branches seen in 0.7% dissections).

Type Ib : Origin of arteria profunda brachii by 3 separate branches seen in 0.3%.

Type II : Arising as a common trunk with superior ulnar collateral in 22.3% cases

Type III : Arising at lower border of teres major so can be considered to be arising from axillary or brachial in 8% cases.

Type IV : Branch of 3rd part of axillary artery in 8.7% cases

Type V : Arising as a common trunk with posterior circumflex humeral in 4% cases

Type VI : Arising as a common trunk with subscapular and both circumflex humeral from axillary artery in 0.7% cases.

Type VII : Absent arteria profunda brachii in 0.7% cases.

J.A.Keen (1961) reported 61% of profunda brachii arising from as a branch of brachial artery. In 13% cases profunda brachii artery arose as a common trunk with superior ulnar collateral. In 26% of his dissection the profunda brachii artery arose from axillary artery.

Anson (1966) said 55% of profunda brachii artery arose from the brachial artery. 22% arose from a common trunk with superior ulnar collateral artery. 7% of profunda brachii artery arose from posterior circumflex humeral artery. He also said 16% of profunda brachii artery arose from axillary artery.

Patnaik *et al.* (2002) said 94% of profunda brachii artery arose from the postero medial aspect of brachial artery. 2% of profunda brachii artery in his dissection arose from common trunk with superior ulnar

collateral artery and 2% from the axillary artery. 2% of profunda brachii as 2 separate branches from brachial artery.

In the present study 87.5% of profunda brachii artery arose from the brachial artery. 5% arose from the common trunk, with the superior ulnar collateral artery, 2.5% from the posterior circumflex humeral artery and 2.5% from the axillary artery. 2.5% of the profunda brachii artery arose as to seperate branches. Regarding the origin of profunda brachii from the brachial artery my study coincides with Patnaik et al. (2002). (Table.9,10,11 & 12).

Regarding the origin of the profunda brachii from the common trunk with superior ulnar collateral, the present study shows 4% which coincides with the scientist Patnaik *et al.* (2002). Profunda brachii originating from the posterior circumflex humeral was found to be 2.5% which almost coincides with the scientist Charies *et al*. (1931) and differs with the scientists J.A.Keen (1961) and Anson (1966). Profunda brachii originating from the axillary artery was found to be 2.5% which coincides with the scientists Patnaik *et al*. (2002).

b. Superior ulnar collateral artery

Charles *et al*. (1931) said that the origin of superior ulnar collateral artery in 22.3% cases was in common with the profunda brachii artery and 77.7 from brachii artery.

Anson (1966) reported 22% of superior ulnar collateral artery arising as a common trunk with profunda brachii artery and 78% from brachial artery.

Patnaik *et al.* (2002) said 2% of superior ulnar artery arising as a common trunk with profunda brachii artery and 2% as a branch of prfounda brachial artery and 96% from brachical artery.

In the present study regarding the origin of superior ulnar collateral artery as common trunk with profounda brachial artery 5%, as a branch profunda brachial 5% from the brachial artery 90%.

c. Nutrient artery

Quains (1844) described that the nutrient artery arose from the brachial artery at the mid level of the upper arm.

Gray (1858) described the nutrient artery as a branch of brachial artery which entered the nutrient canal at the level of the attachment of corocobrachialis muscle.

Poirier (1886) described that nutrient artery entered the nutrient canal at the level of insertion of corocobranchialis muscle.

Piersol (1930) described that nutrient artery arises from brachial artery and enters the nutrient foramen on its medial surface.

Frazer (1937) said that nutrient artery entered the nutrient foramen opposite the lower border of the insertion of the cococobranchialis muscle.

J.C.B.Grant (1957) said that nutrient artery arises from middle of brachial artery and entered the nutrient foramen on the antero-medial surface of the humerus.

C.J.Romanes (1971) said the nutrient artery a branch of the brachial artery entered that nutrient canal on its medial surface.

In the present study, in all the 40 specimens the nutrient artery was the branch of the brachial artery and it arose also out 5 cms proximal to its bifurcation and entered the nutrient canal on its medial surface near the

insertion of the corocobrachialis muscles. So my study coincides with the all the above mentioned anatomists.

d. Inferior ulnar collateral artery

Gray (1858) said inferior ulnar collateral artery begins 5 cms proximal to the elbow and passes behind the median nerve and brachialis muscle.

Huber (1930) said that inferior ulnar collateral artery arises 4 cms above the termination of the brachial artery.

Piersol (1930) said that inferior ulnar collateral artery a branch of the brachial artery arose on its medial side just before its bifurcation.

Frazer (1930) described that the inferior ulnar collateral artery arose 2 cms above the elbow and passes inward on the brachialis muscle.

Anson (1966) described that inferior ulnar collateral artery arose 5 cms proximal to the elbow.

C.J.Romanes (1971) said that inferior ulnar collateral artery arose about 5 cms above the elbow.

Williams *et al.* (1999) said that inferior ulnar collateral artery begins above 5 cms proximal to the elbow.

Yucel A.H. *et al.* (1999) said that inferior ulnar collateral arose from ulnar artery.

Patnaik *et al.* (2002) also discussed that inferior ulnar collateral artery arose from the brachial artery above the elbow and in 4% of his dissection inferior ulnar collateral artery was absent.

In my present study the origin and course of inferior ulnar collateral artery in all the 40 specimen was similar to as described by the Gray, Anson, C.J. Ramanes and Williams et al., But differed from Huber, Persol, Frazwer, Putnaik and Yucel A.H. *et al.* in that I did not fine any absence of inferior ulnar collateral artery.

e. Terminal branches

The brachial artery terminated as ulnar and radial artery below the intercondylar line.

Quains (1844) reported 1.7% of high origin of ulnar artery.

Gruber (1848) reported 2% of high origin of ulnar artery.

Adachi (1928) quoted 0.7% of high bifurcation of brachial artery.

Degaris and Swartley (1928) reported, 0.8% of high origin of radial artery.

McCormack *et al.* (1953) reported 2.26% of high origin of ulnar artery.

J.A.Keen (1961) said 2.8% of ulnar artery arose above the intercondylar line.

In my present study high origin of ulnar artery was observed in 5% of cases, which did not coincide with any of the above mentioned scientists.

Degaris and Swartley (1928) reported 7.7% of high origin of radial artery.

Miller (1939) said 3% of radial artery arose above the intercondylar line.

McCormack *et al.* (1953) reported 14.27% of high origin of radial artery.

Anson (1966) reported 15% high origin of radial artery.

Karisson & Niechajev (1982) reported 10% of high origin of radial artery in their angiographic study.

J.A.Keen (1961) reported 5.9% of high origin of radial artery.

In my present study 5% specimen showed high origin of radial artery, which all most coincide with J.A.Keen.

f. Superficial brachial artery

Quains (1844) reported 0.2% of superficial brachial artery.

Gruper (1848) quoted 0.4% prevalence of superficial brachial artery.

Poirier (1886) said that he had encountered 6% of superficial brachial artery.

Muller (1903) described 1.0% of superficial brachial artery.

Linell (1921) reported 6.0% of superficial brachial artery.

Degaris & Swartley (1928) came across 9% of superficial brachial artery.

Miller (1939) reported 3% of superficial brachial artery.

Treves and Rogers (1947) reported 15% of superficial brachial artery.

McCormack *et al.* (1953) reported 5.75% of superficial brachial artery.

Skopakoff (1959) presented 19.7% of superficial brachial artery.

Lanz & Wachsmith (1959) reported 25% of superficial brachial artery.

J.A.Keen (1961) reported 12.3% of superficial brachial artery.

Fuss et al. (1985) reported 17.0% of superficial brachial artery.

Leppert and Pabst (1985) described 22% of superficial brachial artery.

Baeza *et al.* (1995) described 11.9% of superficial brachial artery.

Kapur *et al*. (2000) described 5% of superficial brachial artery.

Patnaik et al. (2002), reported 6% of superficial brachial artery.

In my present study the prevalence of superficial brachial artery 12.5%. Which coincides with the study of J.A.Keen, Baeza *et al*. and differ from the rest of the above mentioned anatomists. (Table.13).

4. Brachial artery's relation to median nerve

Gray (1848) described that median nerve was lateral to the brachial artery proximally and crossed over to the medial side beyond the insertions of coracobrachialis.

J.C.Boileau Grant (1957), said median nerve was lateral to the branchial artery proximally and medial to it in the distal part of the arm.

Piorier (1886), said that 6% of brachial artery was found superficial to the median nerve.

Linelle (1921), described 5.8% of brachial artery crossed superficial to the median nerve.

Piersol (1930), said that the median nerve was anterolateral to the brachial artery proximally and beyond the insertion of corocobrachialis muscle it was anteriomedial to the brachial artery.

C.J.Romanes (1971), said that the median nerve crossed the brachial artery at the middle of the arm from lateral to medial side.

Patnaik *et al.* (2002), reported 2% of brachial artery superficial to the median nerve.

So in my present study 5% specimens of brachial artery was found superficial to the median nerve. Hence my study coincides with Piorier and Linelle.

II. Foetal cadaveric study

Foetal cadaveric study of the brachial artery was not documented by any author so far. My observatory finding of the fetal cadaveric study in 10 specimens regarding the length of the brachial artery is given in the Table - 6. The average length of the foetal brachial artery was 8.35.

It was noted that in 90% specimens the brachial artery bifurcated below the intercondylar line and in 10% above the intercondylar line.

No variation in the branching pattern of the brachial artery in the foetal study was noted.

The relation of brachial artery to the medial nerve was observed in the foetal study. In 10% specimens the median nerve was found medial to the brachial artery through out its course. In the remaining 90% it was found anterolateral proximally and medial in the distal part of the arm.

CLINICL STUDY

I have studied 2 clinical cases in the age group of 20-25 years; In the above cases alongwith the general investigative procedures, specific investigations like brachial arteriogram (Angiogram) was done.

With the help of the angiograms, I found that brachial artery was the continuation of the the axillary artery in both the cases. Profunda brachial artery arose from the postero medial aspect of the brachial artery and other branches were also visualized.

CONCLUSION

The present study included both (adult and foetal) cadaveric dissection with clinical studies. The results of the study are based on the routine dissection methods, radiological methods and clinical studies. The branching pattern and the variation of the brachial artery in the present study has contributed to our knowledge regarding the relationship, course and the variation of the branching pattern which is of considerable practical importance in the conduct of reparative surgery in arm, forearm and hand.

Their importance lies in the fact that the large artery may occur where the existence of capacious vessels would not ordinarily be expected, because the greater number of aberrant radial and ulnar arteries arise in the proximal half of the arm. The occurrence of accessory major channels through the greater extent of arm is precluded. Consequently, serious secondary haemorrhage might occur in the depth of the wound when the operator has successfully ligated or identified only those vessels which are normally encountered in the area.

Careful scrutiny of the anti cubital area, should be made preceeding simple venipuncture, there is a possibility of entering an aberrant ulnar artery.

Accidental intra arterial injections may lead to gangrene of fingers, hand and fore arm. This accident is facilitated by the superficial course of the ulnar artery of the high origin and by its consistent relationship to the medial basilic and medial anti-brachial veins. The brachial artery itself may be located superficially in the cubital fossa just medial to the biceps tendon. The superficial position of the arteries make them vulnerable to trauma and also make them more accessible to cannulation if needed.

The superficial radial artery and the superficial ulnar artery have been encountered during elevation of the radial forearm flap. The superficial ulnar artery has been suggested on the basis for skin flap. Arteriographic misinterpretation results when the contrast dye is injected distal to the origin of these variant arteries. The existence of the superficial radial artery implies the absence of the normal radial pulse at the wrist level. The recently reported clinical case says that the absence of the ulnar artery was responsible for hand ischaemia after radial artery grafting for coronary bypass.

In my extensive studies, I have found many variations regarding the branches of the brachial artery namely profunda brachii, superior ulnar collateral and the presence of superficial brachial artery high origin of radial and ulnar arteries. All these variations pointed out in this study will warn the medical people before they finalised the therapeutic use.

In this way my findings about the above said "brachial artery and its branching pattern and variations will be definitely helpful and useful to the clinicians of their respective fields.

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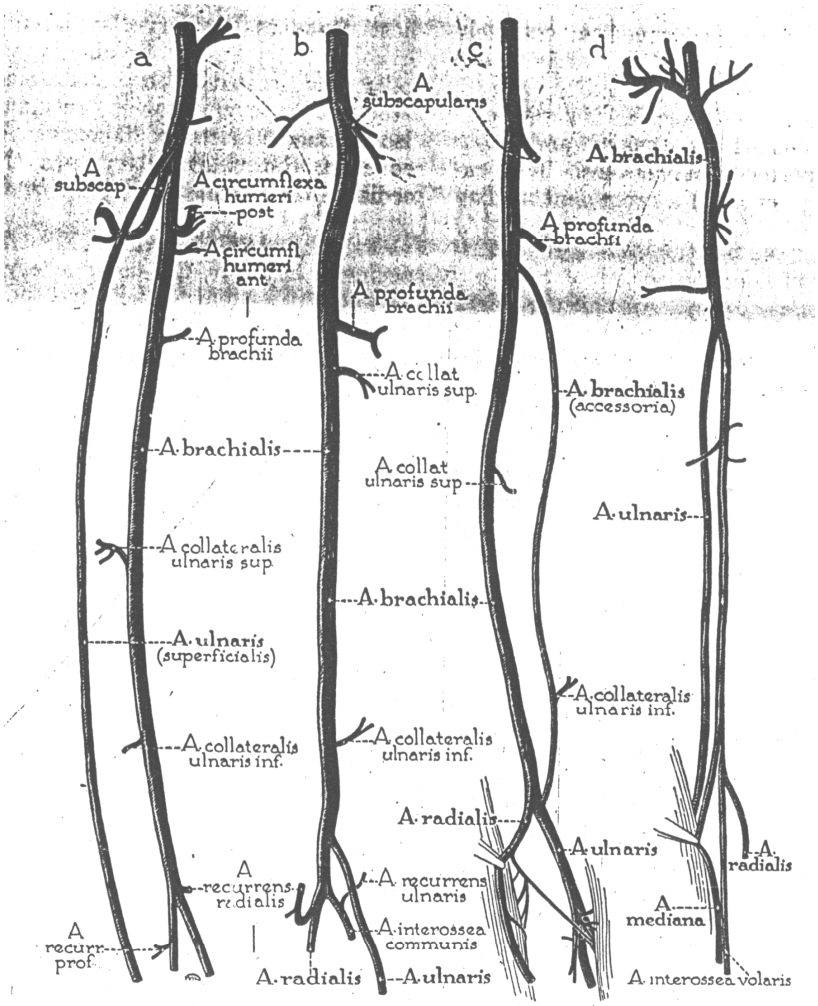
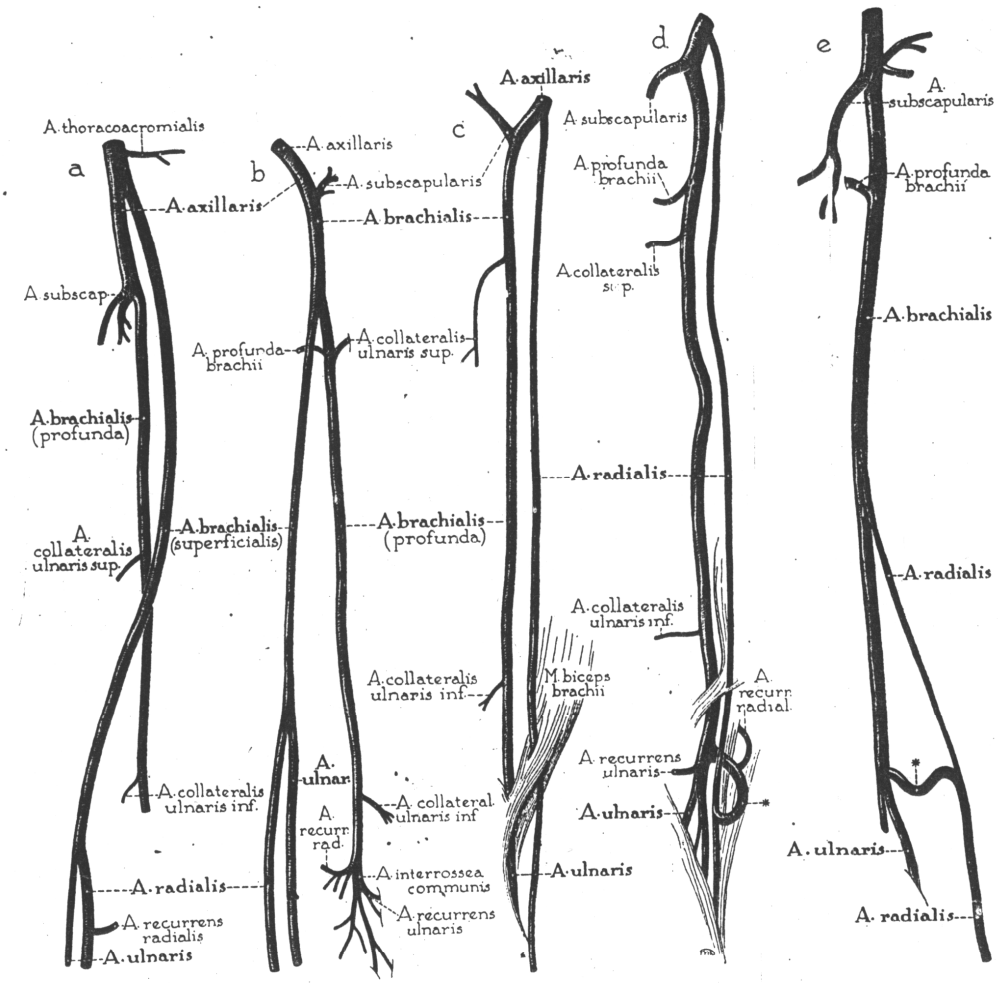
Fig. 1 : VARIATIONS IN THE BRACHIAL ARTERY

(McCORMACK *et al.*, BRACHIAL ARTERIAL PATTERNS)



a, c, d, Variations in the brachial arterial pattern, continued. b, Regular, or "normal," pattern. Dissections schematized to the extent noted in the legend for Figure 2. The specimens departed from the anatomic norm, as recorded in b, in respect to the following features: a superficial ulnar artery in a, which originated from the axillary artery; in c, a looping accessory brachial artery, which, smaller than the companion vessel, joined the ulnar artery in the cubital fossa; in d, a radial artery of high origin which divided in the cubital fossa, into median, superficial radial, and volar interosseous branches.

Fig. 2 : VARIATIONS IN THE BRACHIAL ARTERY
(McCORMACK *et al.*, BRACHIAL ARTERIAL PATTERNS)



Variations in the brachial arterial pattern, examples continued. Showing selected instances of high branching of the main vessel and of communication between axially coursing stems at the level of the cubital fossa. The treatment is schematic in the omission of nonessential musculature and of arterial rami to individual muscles. In addition to proximal brachial or axillary source of the major stems, the following features are noteworthy: in a and b, the occurrence of a paired brachial artery; in c, the passage of a superficial radial artery and an ulnar artery through the substance of the biceps brachii muscle; in d and e, the presence of a large anastomotic connection (at *) between the radial and ulnar arteries in the cubital fossa.

Fig. 3 : DEVELOPMENTAL ANATOMY
UPPER LIMB VASCULATURE

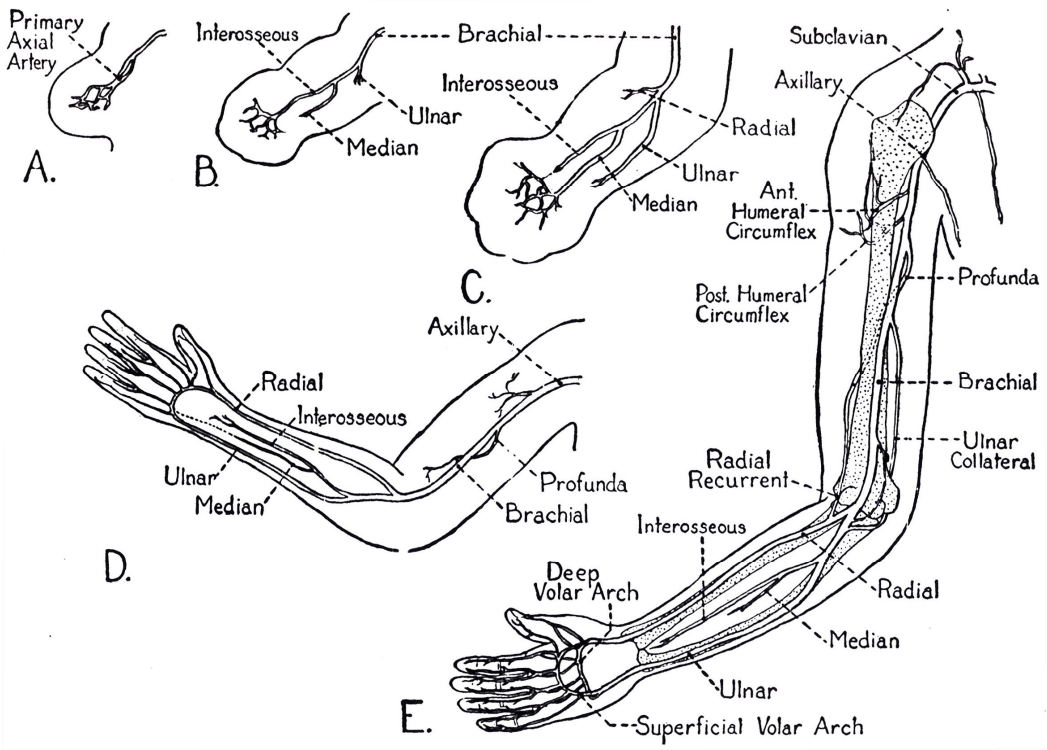


Fig. 4A : OLD THEORY

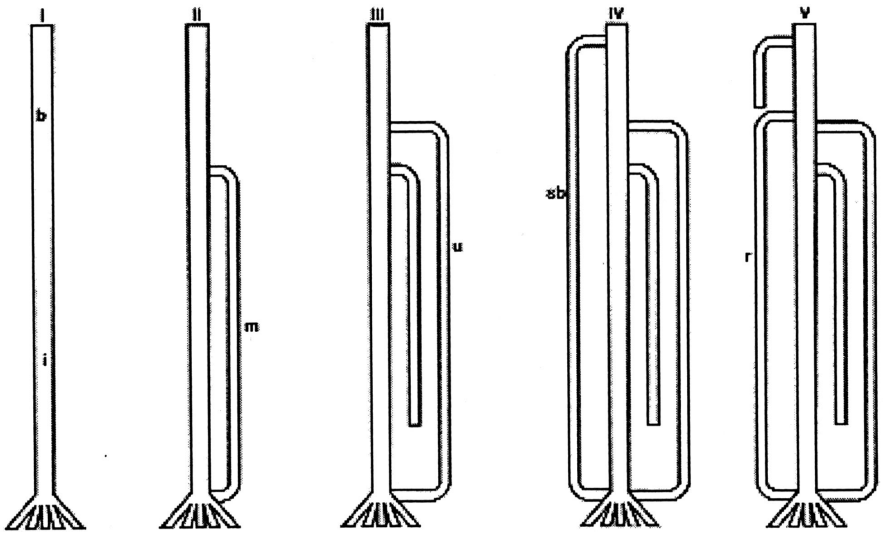


FIG.4B NEW THEORY

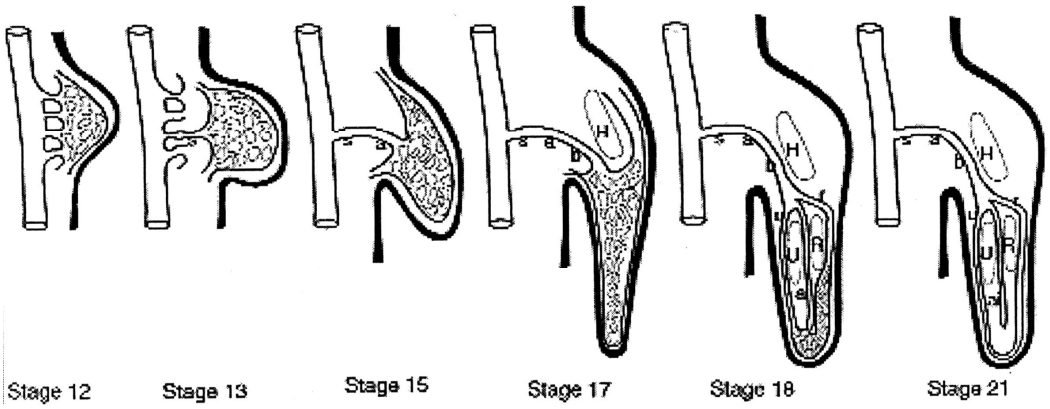
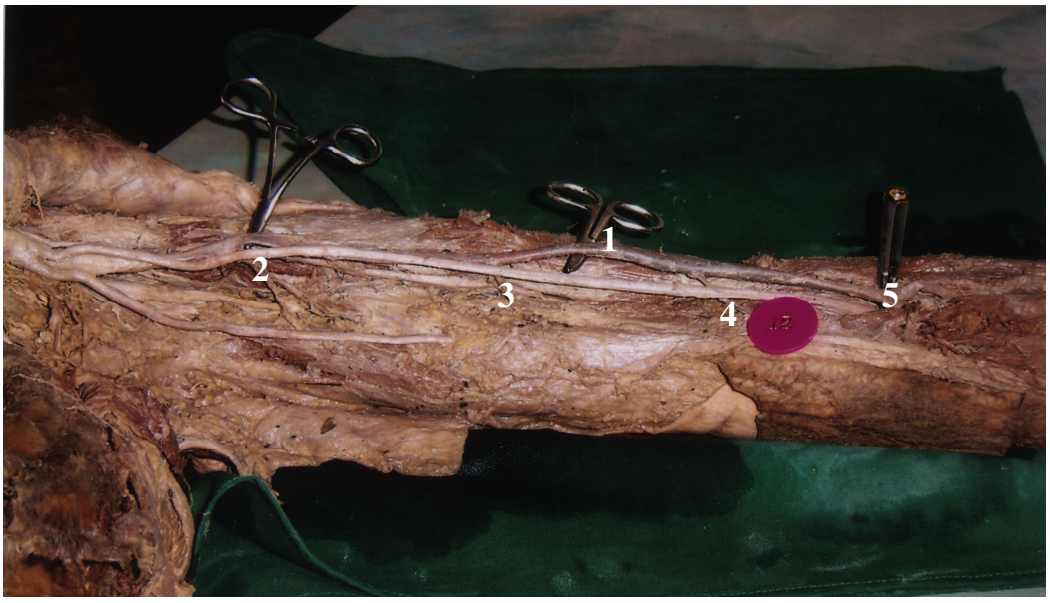


Fig. 5 : NORMAL BRACHIAL ARTERY

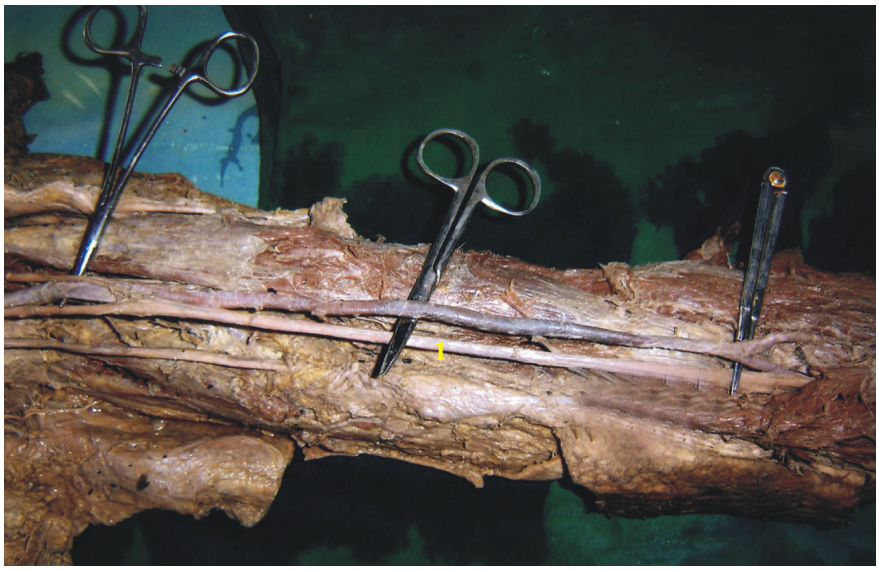


1. **BRACHIAL ARTERY**
2. **PROFUNDA BRACHIAE**
3. **SUPERIOR ULNAR COLLATERAL**
4. **INFERIOR ULNAR COLLATERAL**
5. **TERMINAL BRANCHES - RADIAL & ULNAR**

Fig. 6 : BIFURCATION OF THE BRACHIAL ARTERY ABOVE THE INTERCONDYLAR LINE

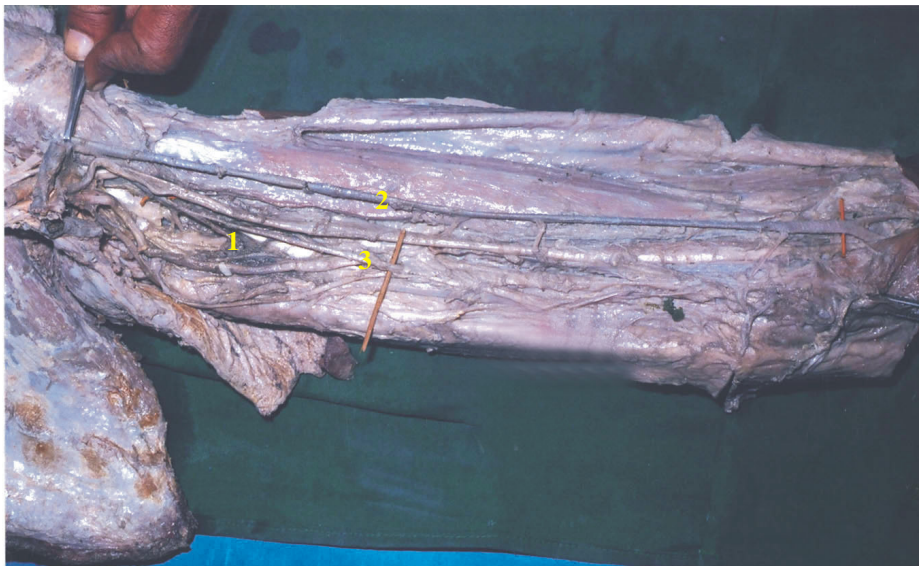
1. POINT OF BIFURCATION OF BRACHIAL ARTERY
2. BRACHIAL ARTERY
3. MEDIAN NERVE

Fig. 7 : BIFURCATION OF THE BRACHIAL ARTERY AT THE INTERCONDYLAR LINE



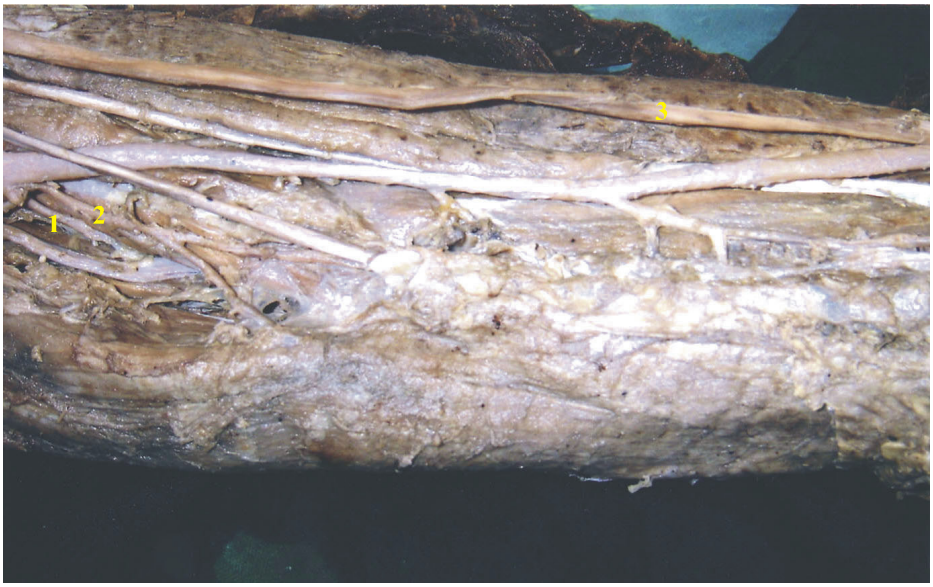
1. POINT OF BIFURCATION OF BRACHIAL ARTERY

Fig. 8 : ORIGIN OF PROFUNDA BRACHII FROM BRACHIAL ARTERY



1. PROFUNDA BRACHII ARTERY
2. BRACHIAL ARTERY
3. SUPERIOR ULNAR COLLATERAL ARTERY

Fig. 9 : PROFUNDA BRACHII FROM COMMON TRUNK WITH SUPERIOR ULNAR COLLATERAL ARTERY

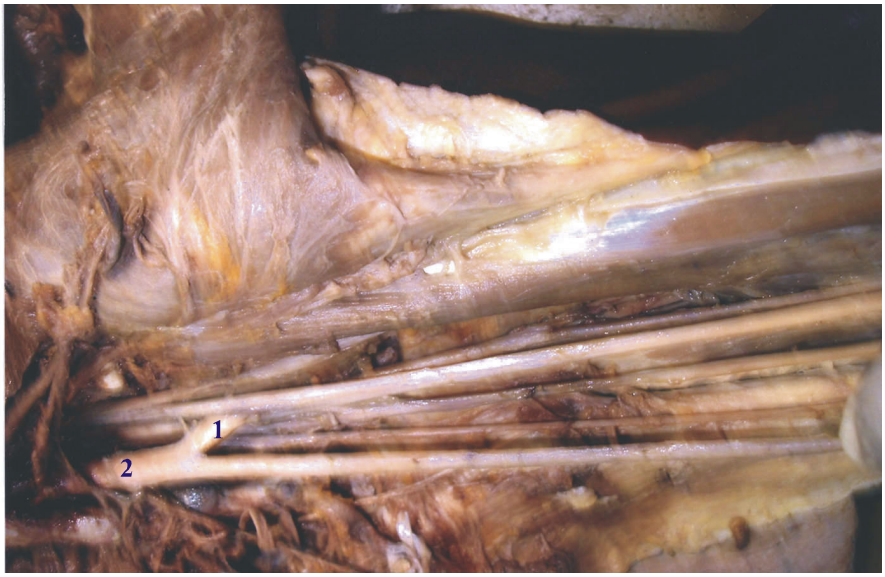


1. ULNAR BRACHII
2. SUPERIOR ULNAR COLLATERAL ARTERY
3. MEDIAN NERVE

Fig. 10 : PROFUNDA BRACHII FROM POSTERIOR CIRCUMFLEX HUMERAL

1. PROFUNDA BRACHII ARTERY

Fig. 11 : PROFUNDA BRACHII FROM AXILLARY ARTERY



1. PROFUNDA BRACHII ARTERY
2. AXILLARY ARTERY

Fig. 12 : PROFUNDA BRACHII ARISING AS TWO SEPARATE BRANCHES

1. } PROFUNDA BRACHII ARTERY
2. }

Fig. 13 : ORIGIN OF SUPERIOR ULNAR COLLATERAL FROM BRACHIAL ARTERY

1. SUPERIOR ULNAR COLLATERAL
2. BRACHIAL ARTERY

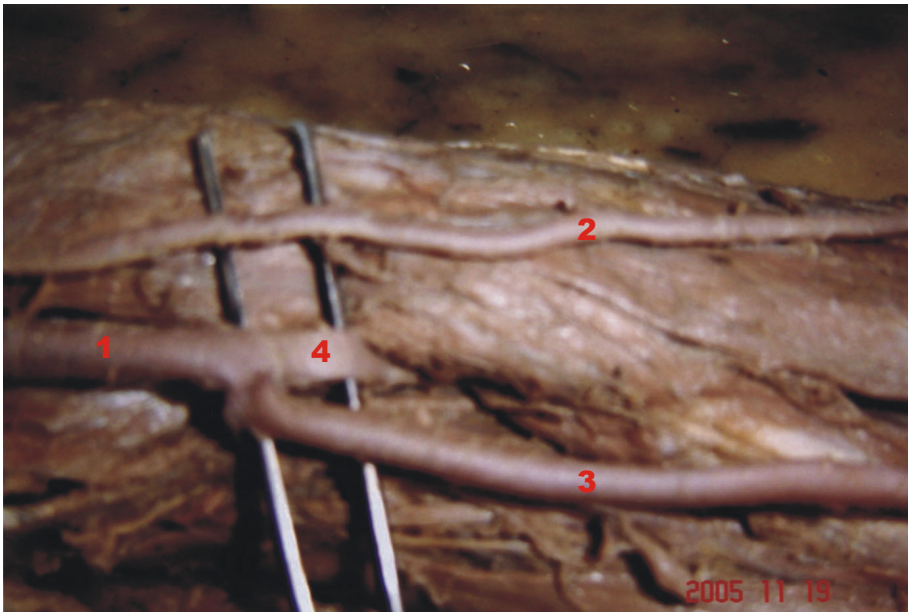
Fig. 14 : ORIGIN OF SUPERIOR ULNAR COLLATERAL FROM COMMON TRUNK WITH PROFUNDA

1. SUPERIOR ULNAR COLLATERAL ARTERY
2. PROFUNDA BRACHII ARTERY

Fig. 15 : ORIGIN OF INFERIOR ULNAR COLLATERAL FROM BRACHIAL ARTERY

1. INFERIOR ULNAR COLLATERAL ARTERY

Fig.16 HIGH ORIGIN OF RADIAL ARTERY

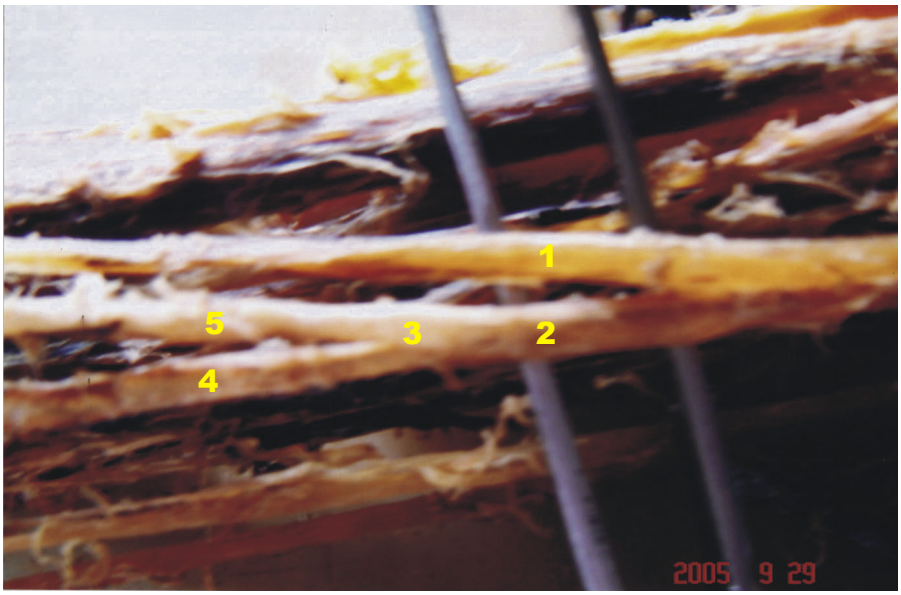


1. BRACHIAL ARTERY
2. HIGH ORIGIN OF RADIAL ARTERY (SUPERFICIAL BRACHIAL)
3. ULNAR ARTERY
4. COMMON INTEROSSEOUS ARTERY

Fig. 17 HIGH ORIGIN OF ULNAR ARTERY

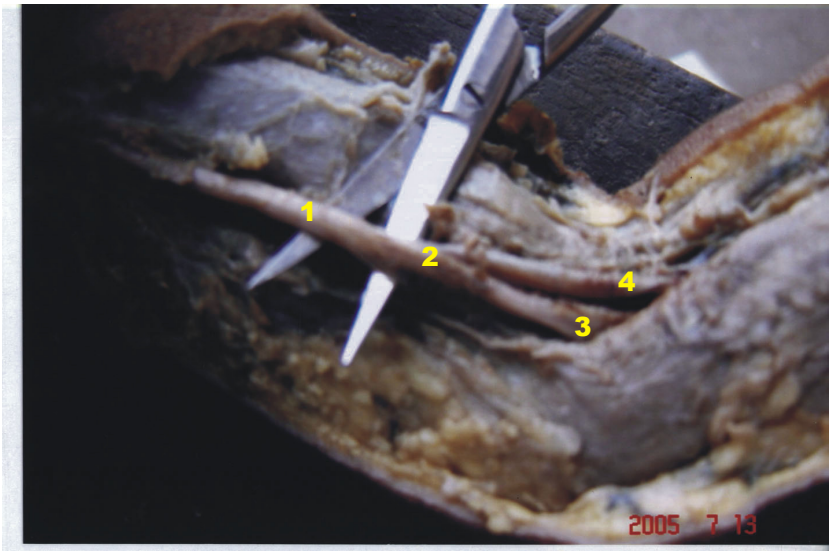
1. AXILLARY ARTERY
2. HIGH ORIGIN ULNAR ARTERY (SUPERFISHIAL BRACHIAL ARTERY)
3. BRACHIAL ARTERY

Fig.18 SUPERFICIAL BRACHIAL ARTERY



1. SUPERFICIAL BRACHIAL ARTERY
2. BRACHIAL ARTERY
3. POINT OF FIBRECATION
4. ULNAR ARTERY
5. COMMON INTEROSSEOUS ARTERY

Fig.19 BIFURCATION OF THE BRACHIAL ARTERY ABOVE THE INTERCONDYLAR LINE



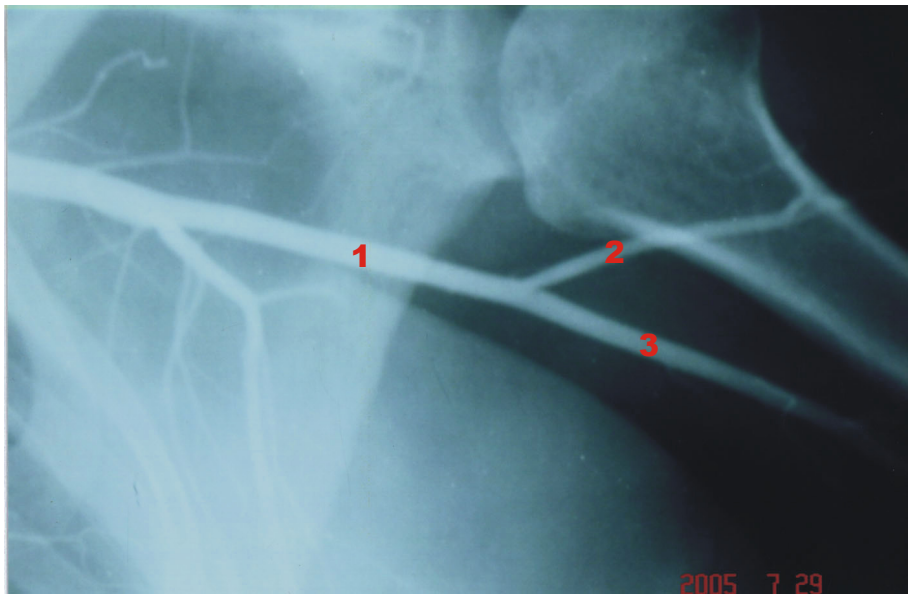
1. BRACHIAL ARTERY
2. POINT OF BIFURCATION
3. ULNAR ARTERY
4. RADIAL ARTERY

Fig. 20 MEDIAN NERVE MEDIAL TO THE BRACHIAL ARTERY THROUGH OUT ITS COURSE

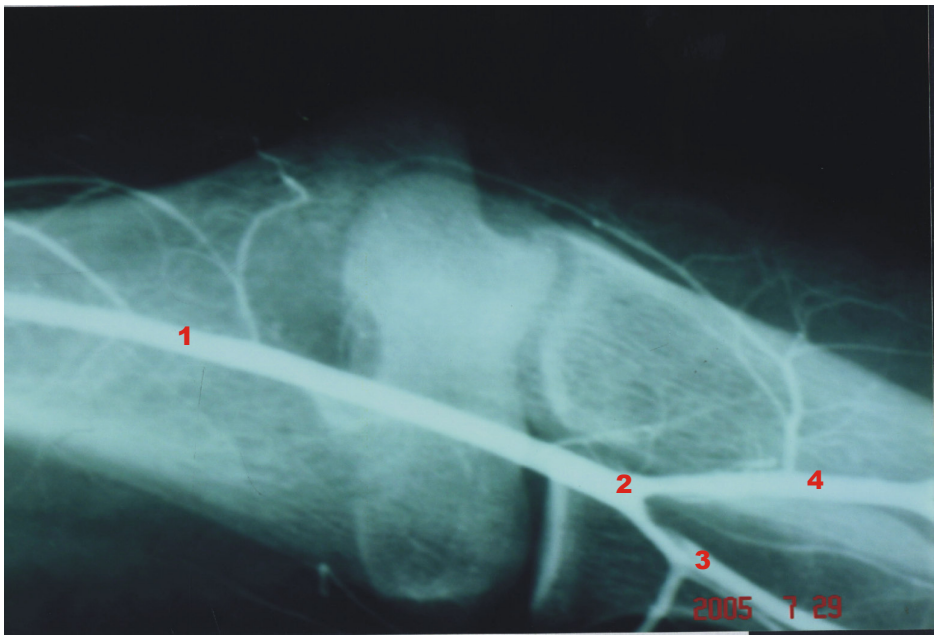
1. MEDIAN NERVE
2. BRACHIAL ARTERY

CLINICAL STUDY

Fig.21 ANGIOGRAPH OF BRACHIAL ARTERY



1. AXILLARY ARTERY
2. PROFUNDA BRACHIAL
3. BRACHIAL



1. BRACHIAL ARTERY
2. POINT OF FIBRECATION
3. RADIAL ARTERY
4. ULNAR ARTERY

ADULT CADAVERIC - PRESENT STUDY

TABLE - 1

LENGTH OF THE BRACHIAL ARTERY FROM THE LOWER BORDER OF TERES MAJOR TO THE POINT OF BIFURCATION

Spec. No.	Length in Cms	Specimen No.	Length in Cms.
1	25	**21**	23.5
2	21	**22**	22.5
3	4	**23**	20
4	22.5	**24**	20
5	20	**25**	22.5
6	22	**26**	21.5
7	21	**27**	2
8	24	**28**	24.5
9	23	**29**	26
10	22	**30**	26
11	25	**31**	23.5
12	24	**32**	24
13	25	**33**	23
14	20.5	**34**	24
15	17.5	**35**	24
16	19.5	**36**	22.5
17	23.5	**37**	23.5
18	20.5	**38**	20.5
19	26	**39**	21
20	20	**40**	22

			AVERAGE LENGTH : 21.5 CM
	VARIABLE	**SPECIMENS IN NUMBER**	**PERCENTAGE**
	Less than 21.5cms	11	28%
	More than 21.5cms	29	72%

THE LENGTH OF BRACHIAL ARTERY FROM THE LOWER BORDER OF TERES MAJOR TO THE POINT OF BIFURCATION

AVERAGE LENGTH : 21.5 CM	
DISTANCE	**PERCENTAGE**
Less than the average distance	28%
More than the average distance	72%

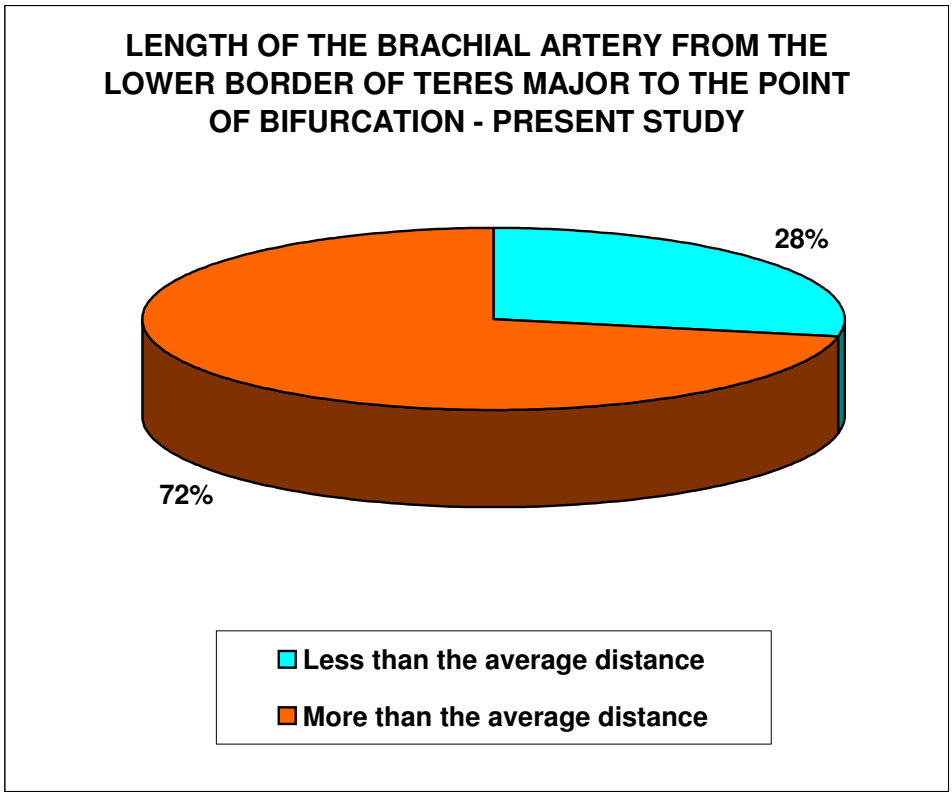


TABLE - 2

POINT OF BIFURCATION IN RELATION TO THE INTERCONDYLAR LINE

DESCRIPTION OF BIFURCATION	NO.OF SPECIMENS	PERCENTAGE
Below the Intercondylar line	36	90%
Above the Intercondylar line	2	5%
AT the Intercondylar line	2	5%

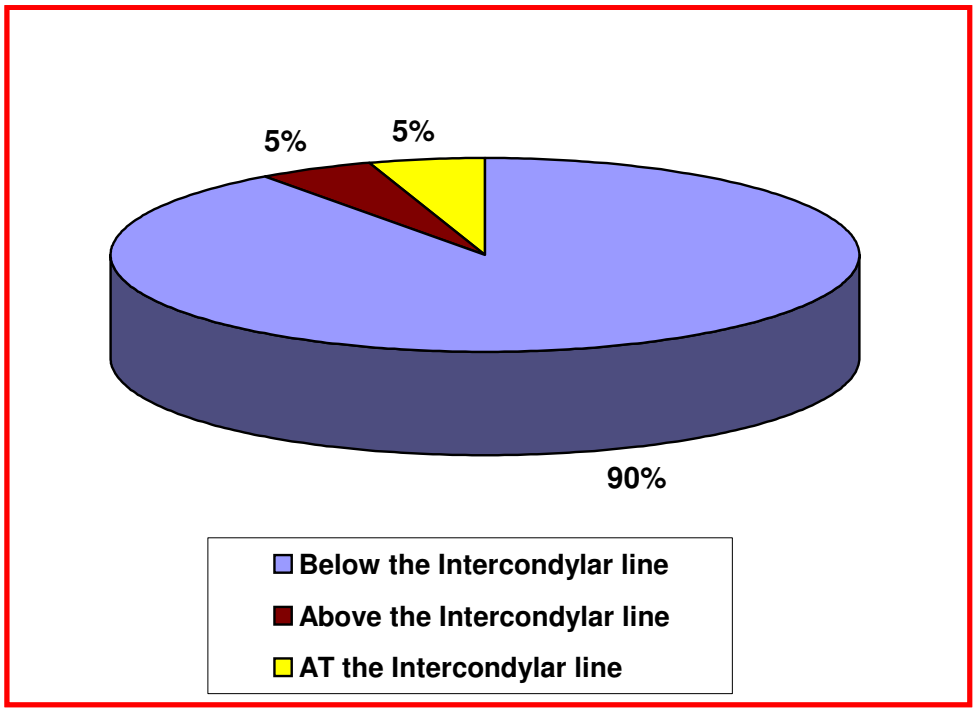


TABLE - 3

ORIGIN OF PROFUNDA BRACHII ARTERY

DESCRIPTION	NO.OF SPECIMENS	PRESENT STUDY (Percentage)
From Brachial artery	35	87.5
Common trunk with superior ulnar collateral artery	2	5
From the posterior circumflex humeral artery	1	2.5
From the axillary artery	1	2.5
Origin by 2 separate branches	1	2.5

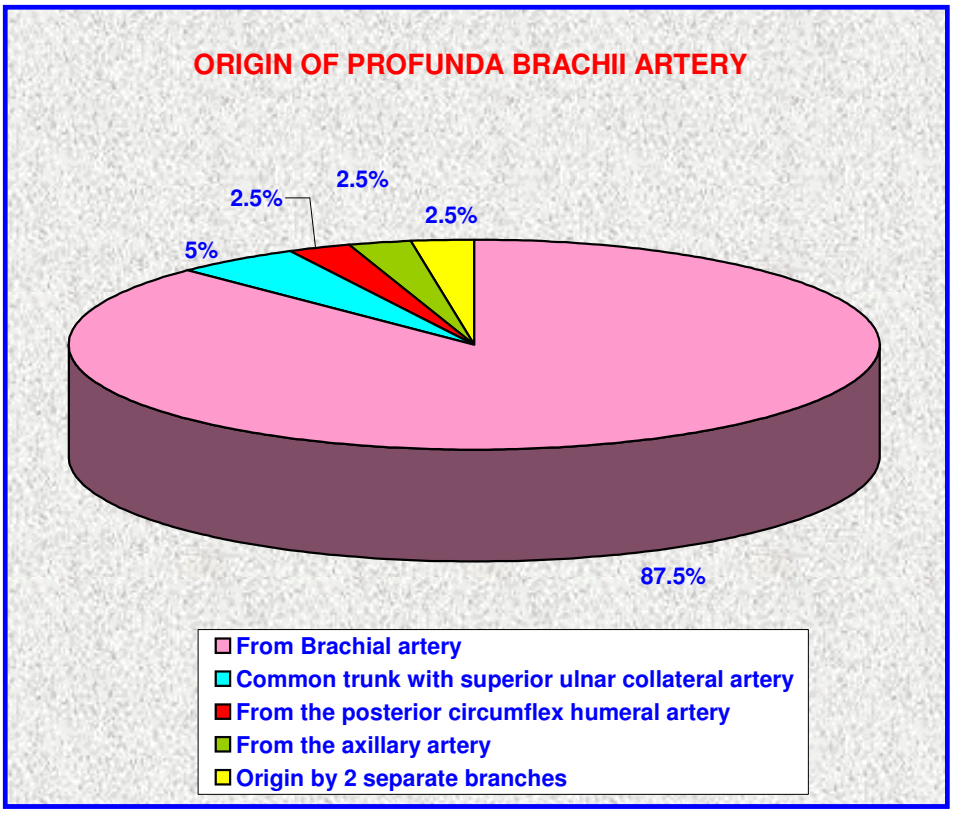


TABLE - 4

ORIGIN OF SUPERIOR ULNAR COLLATERAL ARTERY

DESCRIPTION	NO.OF SPECIMENS	PRESENT STUDY (Percentage)
From Brachial artery	36	90
Common trunk with profunda brachii artery	2	5
From profunda brachii artery	2	5

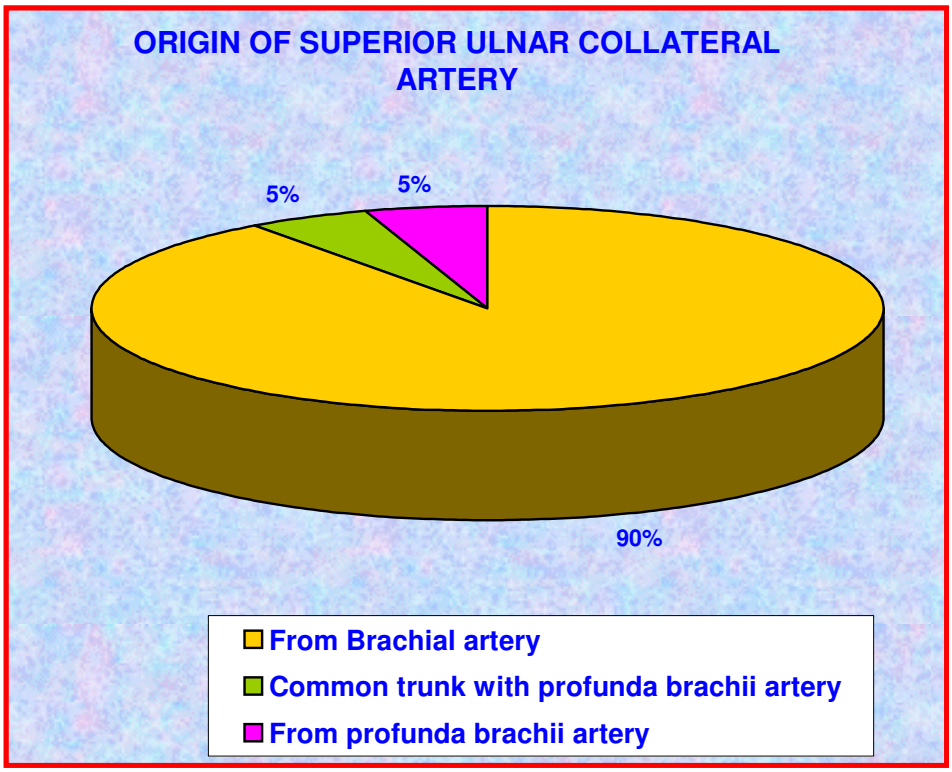


TABLE - 5

BRACHIAL ARTERY'S RELATION TO MEDIAN NERVE

DESCRIPTION	NO.OF SPECIMENS	PRESENT STUDY (Percentage)
Formation of median nerve anterior to the brachial artery	38	95
When formation posterior to the brachial artery	2	5

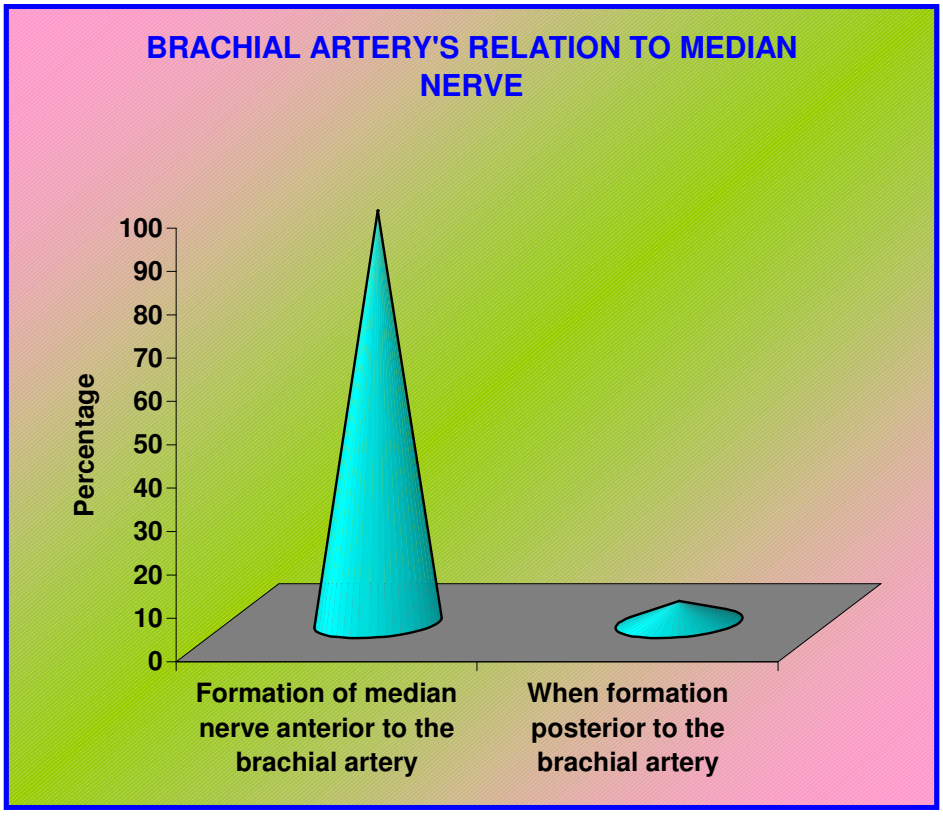


TABLE - 6

FOETAL STUDY - LENGTH OF THE BRACHIAL ARTERY FROM THE LOWER BORDER OF TERES MAJOR TO THE POINT OF BIFURCATION

SPECIMEN NO.	LENGTH IN CMS
1	7.5
2	8
3	9.5
4	8.5
5	10.5
6	10
7	7.5
8	6
9	9.5
10	6.5
Average	8.35

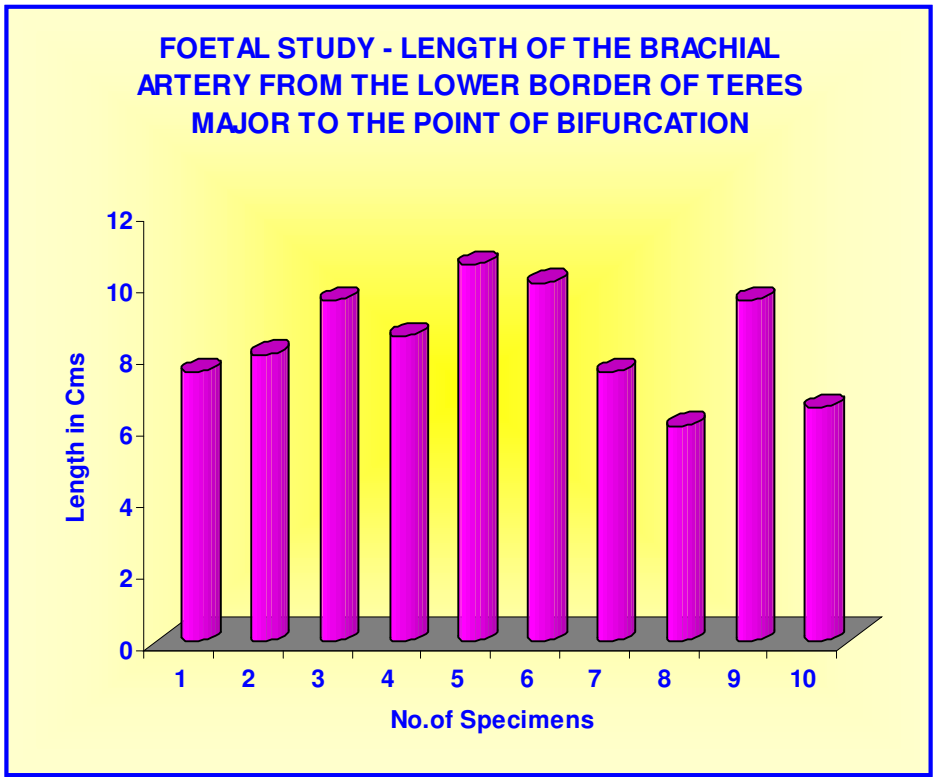


TABLE - 7

LENGTH OF THE BRACHIAL ARTERTY - DISTANCE IN CMS

COMPARISON OF PREVIOUS STUDY RESULTS WITH PRESENT STUDY

	Distance in cm
Patnaik *et al.,*	26.9
Present study	21.5

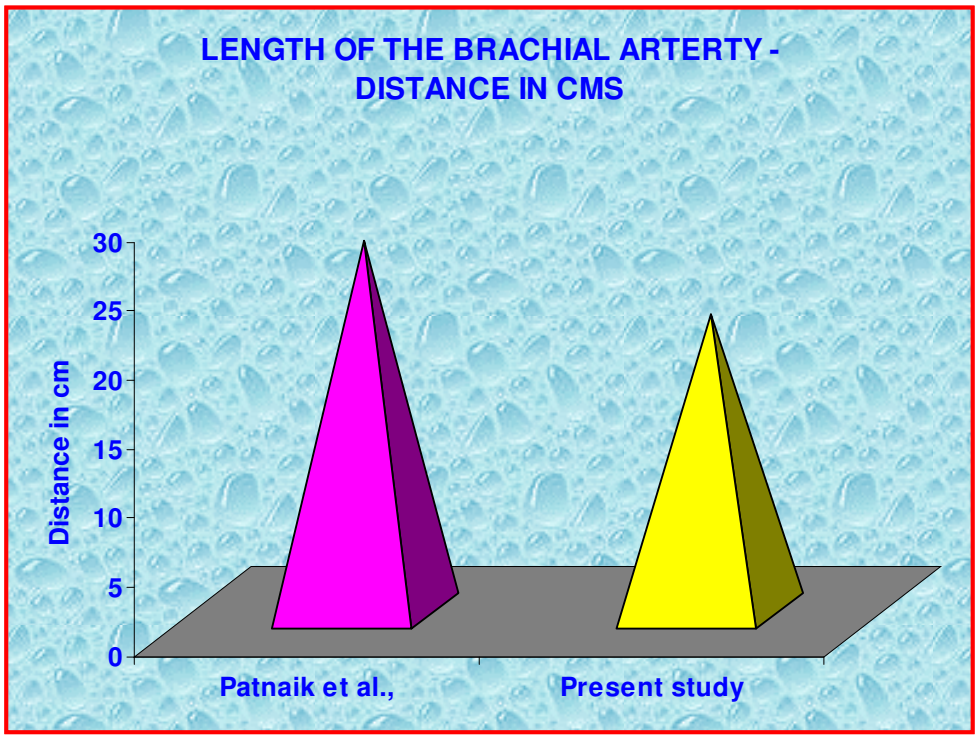


TABLE - 8

POINT OF BIFURCATION OF BRACHIAL ARTERY

ABOVE THE INTERCONDYLAR LINE

COMPARISON OF PREVIOUS STUDIES WITH PRESENT STUDIES

	Percentage
Quains (1844)	1.7
Guruber (1848)	2
Muller (1903)	1
Buntaro Adachi (1928)	0.7
Degaris & Swartley (1928)	0.8
Charles *et al.*(1931)	10
Miller (1939)	3
J.A.Keen (1961)	9
Anson (1966)	15
Karisson & Niechajev (1982)	10
Present study	5

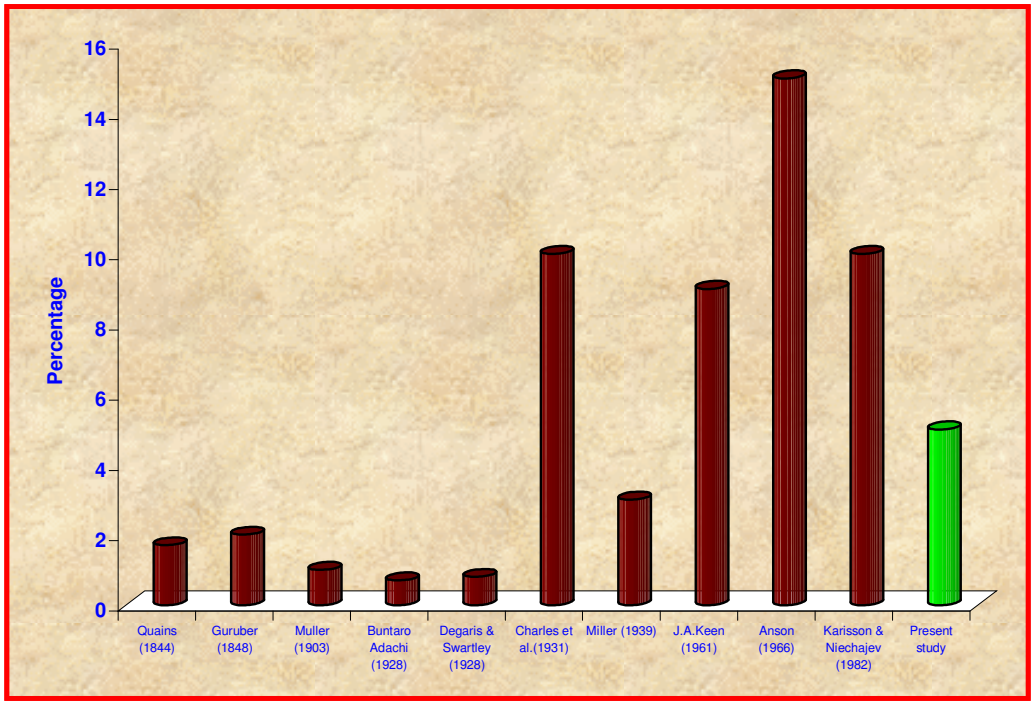


TABLE - 9

SITES AND MODES OF ORIGIN OF PROFUNDA BRACHII

S. No.	Name of the Scientist	Site of Origin	Mode of Origin	Corresponding type of Charles *et al.,* (1931)	% age
1.	Charles *et al.*	Branch of Brachial artery	Postero medial aspect of the brachial artery	Type I	54.7
2.	Anson	Branch of Brachial artery	Postero medial aspect of the brachial artery	Type I	55
3.	Keen	Branch of Brachial artery	Postero medial aspect of the brachial artery	Type I	61
4.	Patnaik	Branch of Brachial artery	Postero medial aspect of the brachial artery	Type I	94
5.	Present Study	Branch of Brachial artery	Postero medial aspect of the brachial artery	Type I	87.5

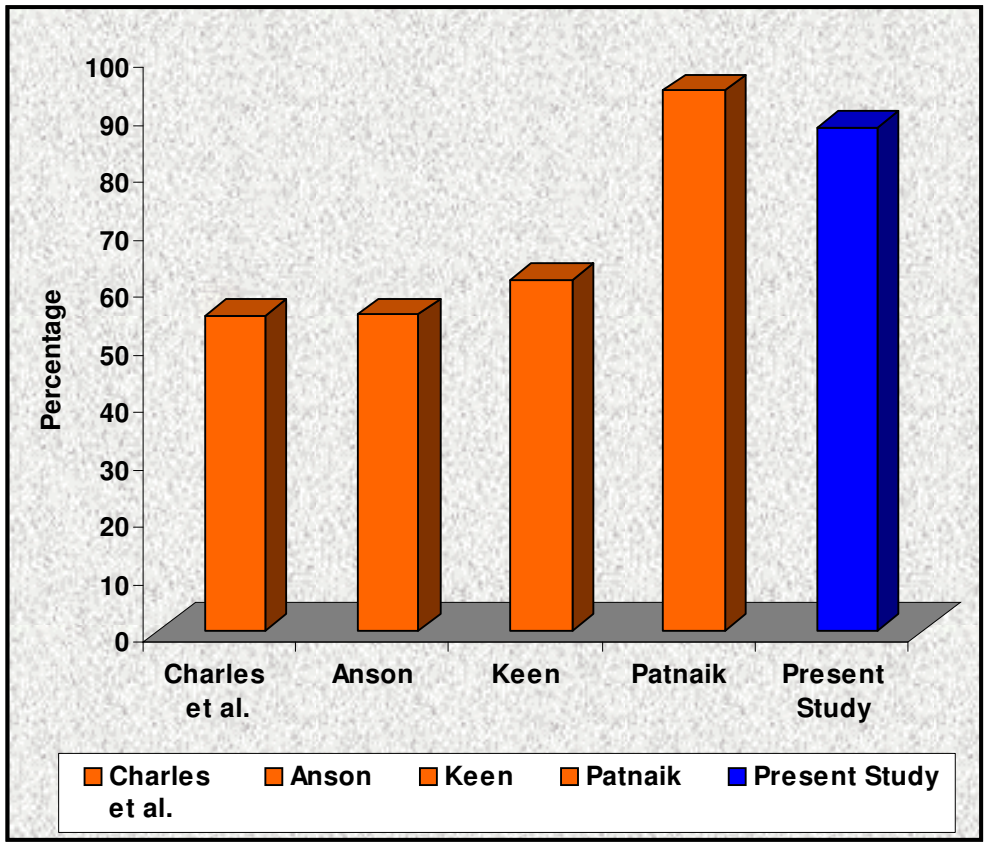


TABLE - 10

SITES AND MODES OF ORIGIN OF PROFUNDA BRACHII

S. No.	Name of the Scientist	Site of Origin	Mode of Origin	Corresponding type of Charles *et al.*, (1931)	% age
1.	Charles *et al.*	Branch of Brachial artery	By two separate branches	Type Ia	0.7
2.	Patnaik	Branch of Brachial artery	By two separate branches	Type Ia	2
3.	Present Study	Branch of Brachial artery	By two separate branches	Type Ia	2.5

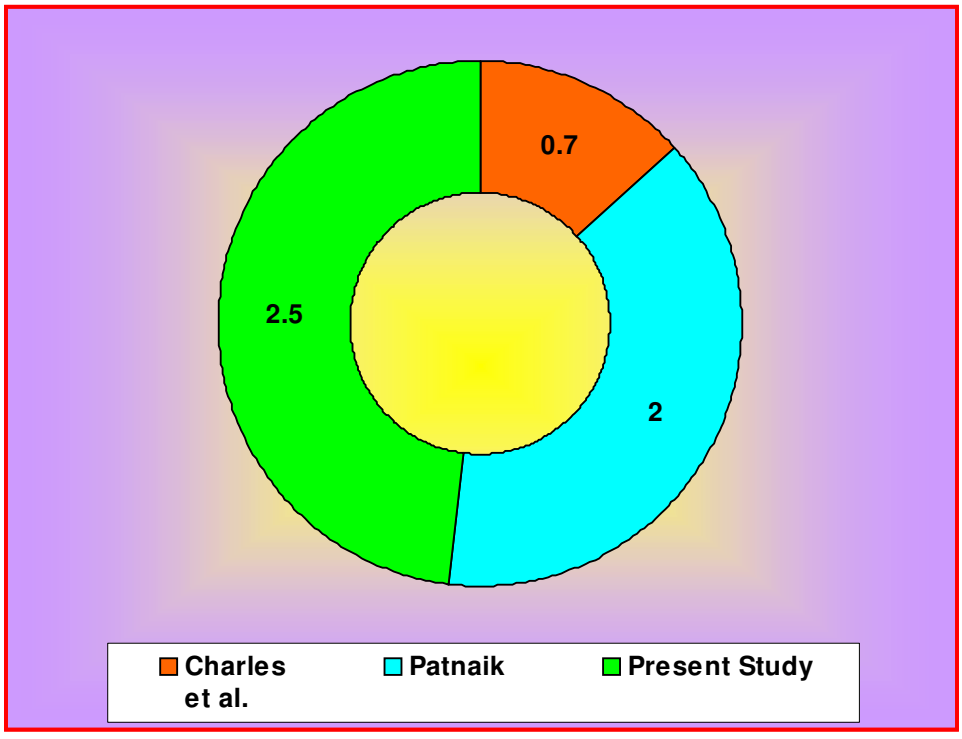


TABLE - 12

SITES AND MODES OF ORIGIN OF PROFUNDA BRACHII

S. No.	Name of the Scientist	Site of Origin	Mode of Origin	Corresponding type of Charles *et al.,* (1931)	% age
1.	Charles *et al.*	Branch of Brachial artery	Common trunk for profunda and superior ulnar collateral artery	Type II	22.3
2.	J.A.Keen	Branch of Brachial artery	Common trunk for profunda and superior ulnar collateral artery	Type II	13
2.	Anson	Branch of Brachial artery	Common trunk for profunda and superior ulnar collateral artery	Type II	22
3.	Patnaik	Branch of Brachial artery	Common trunk for profunda and superior ulnar collateral artery	Type II	2
4.	Present Study	Branch of Brachial artery	Common trunk for profunda and superior ulnar collateral artery	Type II	5

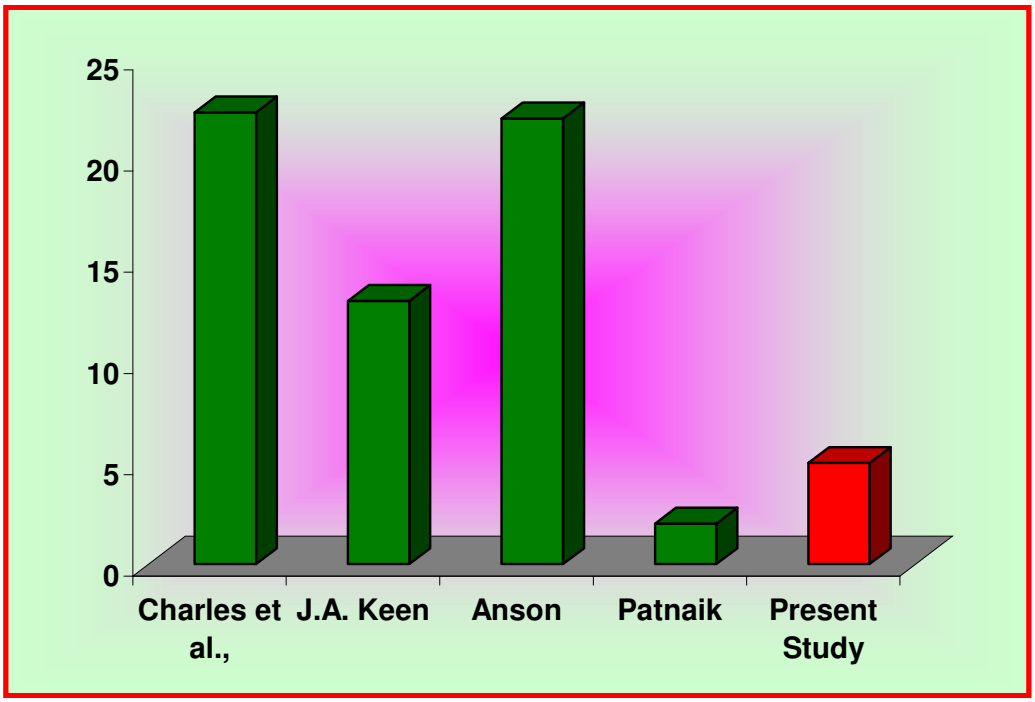


TABLE - 11

SITES AND MODES OF ORIGIN OF PROFUNDA BRACHII

S. No.	Name of the Scientist	Site of Origin	Mode of Origin	Corresponding type of Charles *et al.,* (1931)	% age
1.	Charles *et al.*	Posterior circumflex humeral	-	Type V	4
2.	Anson	Posterior circumflex humeral	-	Type V	7
3.	Present Study	Posterior circumflex humeral	-	Type V	2.5

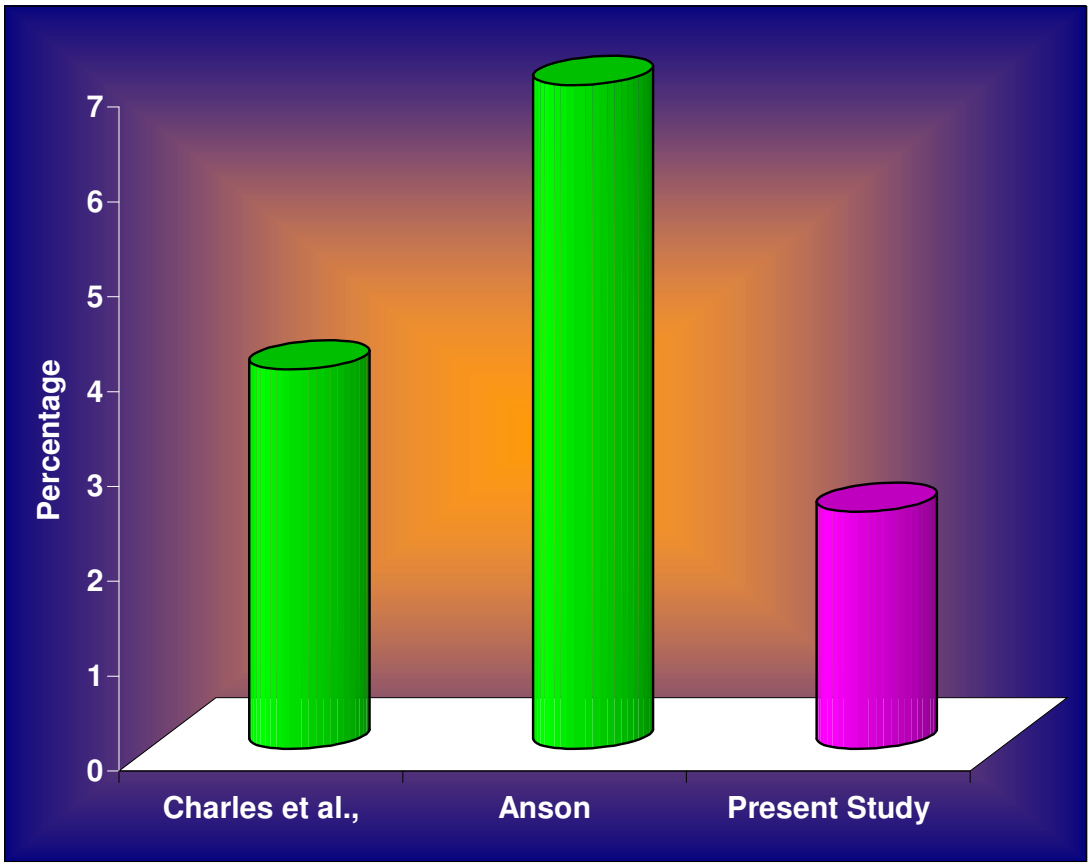
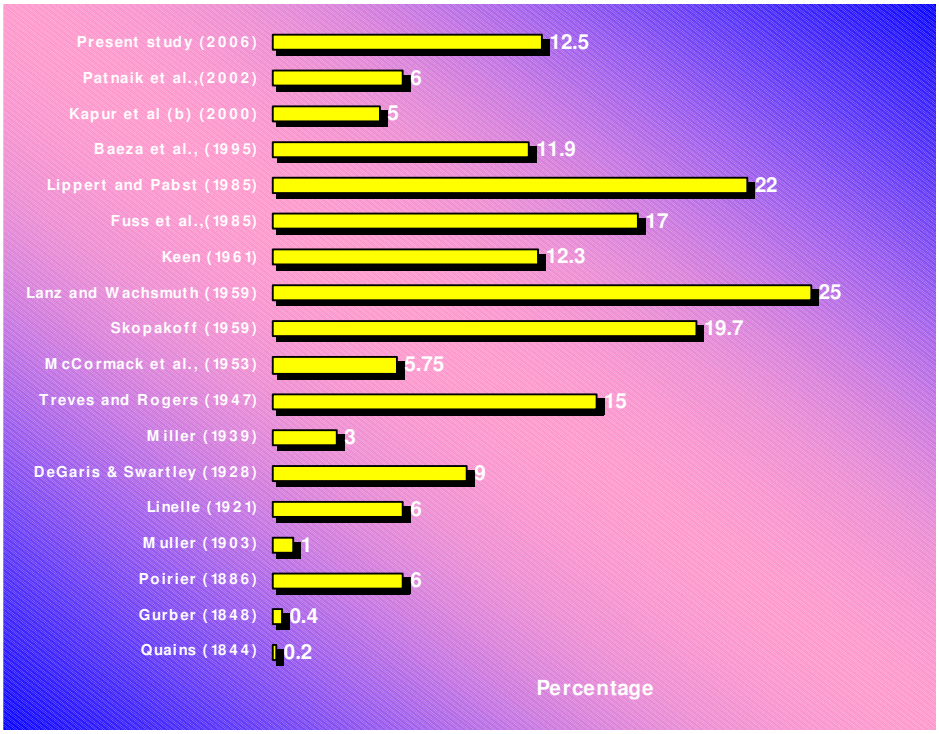


TABLE - 13

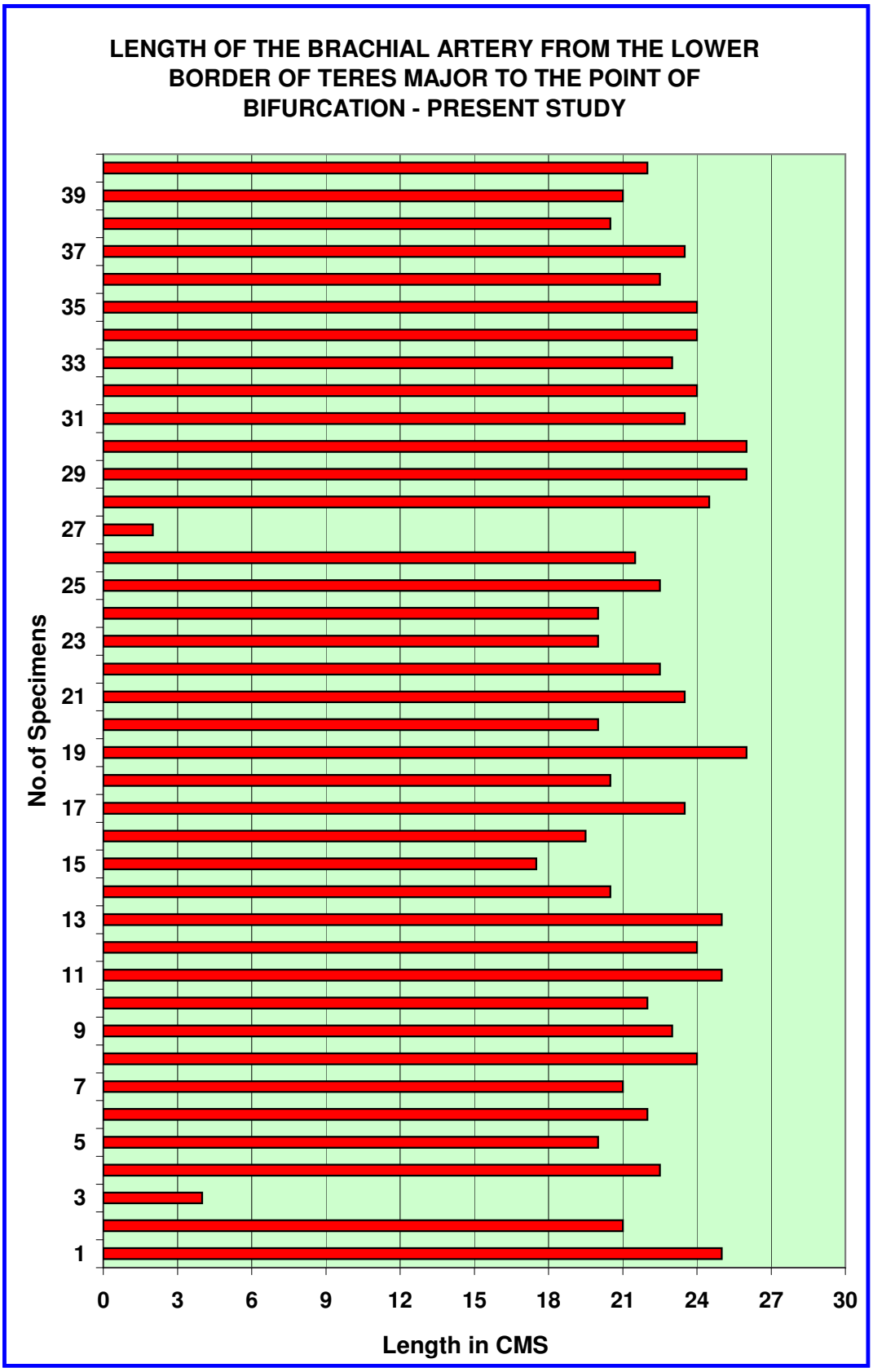
PREVALENCE OF SUPERFICIAL BRACHIAL ARTERY

Sl.No.	Name of the author	Year	%age
1.	Quains	1844	0.2
2.	Gurber	1848	0.4
3.	Poirier	1886	6.0
4.	Muller	1903	1.0
5.	Linelle	1921	6.0
6.	DeGaris and Swartley	1928	9.0
7.	Miller	1939	3.0
8.	Treves and Rogers	1947	15.0
9.	McCormack *et al.,*	1953	5.75
10.	Skopakoff	1959	19.7
11.	Lanz and Wachsmuth	1959	25.0
12.	Keen	1961	12.3
13.	Fuss *et al.,*	1985	17.0
14.	Lippert and Pabst	1985	22.0
15.	Baeza *et al.,*	1995	11.9
16.	Kapur *et al* (b)	2000	5.0
17.	Patnaik *et al.,*	2002	6.0
18.	Present study	2005	12.5



ORIGIN OF SUPERIOR ULNAR COLLATERAL ARTERY

AUTHOR	DESCRIPTION	PERCENTAGE
Charles	Common trunk with profunda brachii	22.3
	From the brachial artery	77.7
	As a branch of profunda brachii	0
Anson	Common trunk with profunda brachii	22
	From the brachial artery	78
	As a branch of profunda brachii	0
Patnaik	Common trunk with profunda brachii	2
	From the brachial artery	96
	As a branch of profunda brachii	2
Present Study	Common trunk with profunda brachii	5
	From the brachial artery	90
	As a branch of profunda brachii	5


LENGTH OF THE BRACHIAL ARTERY FROM THE LOWER BORDER OF TERES MAJOR TO THE POINT OF BIFURCATION - PRESENT STUDY
No.of Specimens
39
37
35
33
31
29
27
25
23
21
19
17
15
13
11
9
7
5
3
1
0
3
6
9
12
15
18
21
24
27
30
Length in CMS